The Quebec City Conference 2014

PPF

Participant's Guide

Including important background information on each session

Public Policy Forum on Venture Capital and Innovation

Quebec City, October 21 and 22, 2014

MESSAGE FROM THE QUEBEC CITY CONFERENCE PRESIDENT

It is our great pleasure to welcome you to the Quebec City Conference's ("QCC") Public Policy Forum on Venture Capital and Innovation ("PPF").

Each year this international platform gives participants an opportunity to exchange views, experiences and concerns regarding public policies in support of a buoyant venture capital ecosystem for financing emerging technology companies. Its proximity with the Institutional Investors Roundtable allows its participants to engage with leading institutional investors from around the world having a renewed interest in the financing of innovation.

None of this would be possible without our wonderful sponsors, volunteers and organizers and everyone else who has worked so hard to make this Conference a success. We can never thank you enough.

We would like to thank, in particular, the governments that supported the Public Policy Forum, financially and logistically. We salute the government of France, through Bpifrance Le Lab, which joined the governments of Canada, Quebec, Ontario and British Columbia as partners in this project. They came together based on the conviction that joining forces, resources and expertise is the right strategy to maximize value for each participant. We believe that this generous and visionary precedent will also benefit other jurisdictions faced with a common challenge of creating wealth through innovation.

We hope all of you enjoy and benefit from your participation at this renewed PPF, while seeing old friends and developing new and lasting relationships

Sincerely,

Christian Racicot
Co-Founder & President

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Résumés

Gilles Duruflé

Executive Vice President
The Quebec City Conference
President
Public Policy Forum on Venture Capital and Innovation

Gilles Duruflé is presently Executive Vice President of the Quebec City Conference and President of the Public Policy Forum. He is also an independent consultant advising venture capital and private equity funds, institutional investors and governments.

He was until 2004 Senior Partner at CDP Capital Technology Ventures, the venture capital subsidiary ot the Caisse de dépôt et placement du Québec, in charge of the Funds of funds portfolio, investing in North American and European VC funds.

He was previously Head of strategic studies at the Caisse de dépôt et placement du Québec. From 1979 to 1991, he worked as Senior Partner in strategic consulting firms in the CDC Group (Caisse des dépôts et consignations, Paris) in Europe and North America.

He is a Vice President of the Canadian Venture Capital Association (CVCA).

M. Duruflé obtained his Masters in Philosophy from the CERP (Paris), his Ph.D. in Mathematics from the Paris VI University and the Diploma of the Centre d'Études des Programmes Économiques (Ministry of Finance, Paris). He is a CFA and has published numerous books and articles on various subjects related to economics and finance.

Yigal Erlich

Chairman
Public Policy Forum on Venture Capital and Innovation
Founder, Chairman and Managing Partner
The Yozma Group

Mr. Yigal Erlich is the founding father of the Israeli venture capital industry and one of the most prominent figures in the Israeli high-tech arena in the past 15 years.

At the beginning of the 1990s, Mr. Erlich identified a market failure and a huge need in to establish for the first time a professionally-managed venture capital industry that will fund the exponential growth of high tech ventures coming out of.

In late 1992, Mr. Erlich convinced the Israeli government to allocate $100 million for his venture capital vision. Within a period of three years, Erlich, along with the other members of the core team at Yozma, established ten venture funds. These ten funds, which include Gemini, JPV, Nitzanim (Concord), Polaris (Pitango), STAR, Walden and Vertex, are the backbone of the vibrant and sophisticated venture capital market that has today.

Mr. Yigal Erlich is the founder of the Israel Venture Association and served as its first Chairman. Between 1984 and 1992, Mr. Erlich served as the Chief Scientist of the Ministry of Industry and Trade. During his eight-year tenure as Chief Scientist, Mr. Erlich commanded an annual budget of $200 million, primarily directed at research and development projects of high-technology companies. In addition, Mr. Erlich initiated the Generic Technology program which fostered cooperation on long-term R&D activities through the creation of consortia of companies with research institutes and universities worldwide.

Mr. Erlich also started the Technology Incubator Program that led to the creation of 24 Incubation Centers throughout. Mr. Erlich was instrumental in the establishment of several bi-national industrial and technology R&D cooperation agreements with US and other countries. Mr. Erlich was the Chairman of the Executive Committee of the US-Israel Bi-national Industrial Research and Development Foundation (BIRD), and a Director of the Dead Sea Works, Israel Chemicals, Israel Oil Refineries, Hadassah's commercialization company - Hadassit, and the Technion Research and Development Co. Ltd; he is a director in RVC (Russian Venture Company).

Mr. Erlich holds B.Sc. and M.Sc. in Chemistry and an MBA from the Hebrew University of Jerusalem.

Introduction by the President & Chairman of the Public Policy Forum on Venture Capital and Innovation ("PPF")

Innovation is the main driver of growth in modern economies. An outgrowth of the Quebec City Conference that aims to be the Davos of the international community of **private long-term investors**, the PPF is concerned with the innovation ecosystem along with its best practices and success factors from an **investment and public policy perspective**.

2014 Program Highlights

One of the main themes of the 2014 edition of the PPF will be "Fostering Entrepreneurship within Universities". Building on the discussions of previous PPFs (Accelerators in 2012 and Crowdfunding in 2013), the objective will be to continue to explore how the early stage landscape for entrepreneurial finance is being transformed and the potential implications of these transformations for next-generation public policies.

Other topics addressed during plenary sessions will include:

- Institutional investors' perspectives on the financing of innovation;
- International perspectives: the Taiwanese model to link research institutions, large corporations, and financing instruments to create new startups.

In the afternoon, actively moderated breakout sessions will allow for more direct interaction among participants around themes that are regularly discussed at the PPF:

- "How do changes in the early stage environment affect the evolution of venture capital models? How can public policies find a balance in the support they provide to early vs. later stage financing?"
- "How do university innovation initiatives fit into the broader early stage financing environment?"
- "Which LP funding models are working? What will it take to interest institutional investors in VC? Can VCs get funded from alternative LPs, such as corporates?"

Our speakers and panellists, as well as our audience, are composed of public policy makers and industry leading GPs, LPs, academics and other industry experts from four continents who all have interest and high level experience in advocating, designing and implementing public policies in support of a buoyant venture capital ecosystem to finance emerging technology companies. This should set the stage for what we hope will be intense discussions and high quality networking.

We would like to thank all those who contributed to this Forum: Professor Josh Lerner, our special advisor, Professor Ajay Agrawal and Professor Thomas Hellmann and our Advisory Committee, as well as the directors of the Québec City Conference who have enthusiastically supported this endeavour.

A special “thank you” goes to the Governments of Quebec, Canada, Ontario, British-Columbia and France through Bpifrance Le Lab, which partnered with the Québec City Conference to develop this Forum and have provided a great deal of financial and technical support.

We hope you will find the documents contained in this Participant’s Guide interesting and wish you a very successful Forum.

Yigal Erlich

Chairman
Public Policy Forum on Venture Capital and Innovation
Founder, Chairman and Managing Partner
The Yozma Group

Gilles Duruflé

Executive Vice President
The Quebec City Conference
President
Public Policy Forum on Venture Capital and Innovation

Advisory Committee

SPECIAL ADVISOR

Josh Lerner
Jacob H. Schiff Professor of Investment Banking
Harvard Business School

ADVISORS

Ajay Agrawal
Peter Munk Professor of Entrepreneurship
Rotman School of Management
University of Toronto

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CEO
New Zealand Venture Investment Fund

Cedric Bisson
Venture Partner
Teralys Capital

Thomas Hellmann
Professor of Entrepreneurship and Innovation
Saïd Business School
Oxford University

John Marshall
President & CEO
Board of Director
Ontario Capital Growth Corporations

PROGRAM

TUESDAY, OCTOBER 21ST

PPF PRECONFERENCE

HILTON HÔTEL, 1100 boul. René-Lévesque Est

The PPF preconference is open to PPF participants and to selected local entrepreneurs and leaders.

It is designed to create an opportunity for PPF participants to meet and interact with them around high profile thought leaders on technology and innovation.

A 3-course dinner will be served and it will conclude with a cocktail.

Time	Event
5:15 pm	**REGISTRATION**
6:00 pm	**Introductory Remarks**

Dr. Gilles Duruflé
Executive Vice President
The Quebec City Conference
President
QCC Public Policy Forum on Venture Capital and Innovation

Welcome remarks

Mr. Régis Labeaume
Mayor of Quebec City

"Financing innovation in Canada"

Mr. Jérôme Nycz
Executive Vice President
BDC Capital

Time	Event

"Financing innovation in Canada: the FSTQ experience in Venture Capital"

Mr. Alain Denis
Senior Vice President - New Economy
Fonds de solidarité FTQ

7:00 pm **Keynote Speaker**

Mr. Jeff Bussgang
General Partner
Flybridge Capital Partners (Boston)

Author of "Mastering the VC Game: A Venture Capital Insider Reveals How to Get from Start-up to IPO on Your Terms"

Introduced by

Ms. Sylvie Pinsonnault
Vice President, Investment Funds, Business Immigration and Tax Measures
Investissement Québec

Concluding Remarks

Mr. Christian Dubé
Executive Vice President Québec
Caisse de dépôt et placement du Québec

8:00 pm **NETWORKING COCKTAIL**

WEDNESDAY, OCTOBER 22nd

PUBLIC POLICY FORUM ON VENTURE CAPITAL AND INNOVATION

Time	Event	Venue
7:15 am	**BREAKFAST AND REGISTRATION**	*Salon Jacques-Cartier, Fairmont Le Château Frontenac*
8:30 am	**WELCOME REMARKS**	*Frontenac Room, Fairmont Le Château Frontenac*

Mr. Yigal Erlich
Founder, Chairman and Managing Partner
The Yozma Group (Israel)
Chair
Public Policy Forum on Venture Capital

INTRODUCTION

Dr. Gilles Duruflé
President
Public Policy Forum on Venture Capital

8:50 am **KEYNOTE PRESENTATION**

Dr. Josh Lerner
Jacob H. Schiff Professor of Investment Banking
Harvard Business School

9:50 am	**NETWORKING BREAK**	*Petit Frontenac Room*

Time	Event	Venue
10:15 am	**FIRST PANEL: "Fostering Entrepreneurship within Universities"** **Part One: "University science and failures in the market for entrepreneurial judgment: economics of university accelerators – A case study"**	*Frontenac Room*

Presentation and moderator

Dr. Ajay Agrawal
Peter Munk Professor of Entrepreneurship
Rotman School of Management
University of Toronto (Canada)

Panelists

Mr. Michael Helander
Co-founder and President
OTI Lumionics Inc. (Canada)

Mr. Karl Martin
Co-founder and CEO
Bionym Inc. (Canada)

Mr. Jesse Rodgers
Director
Creative Disruption Lab (Canada)

Time	Event	Venue
	Part two: "Contrasting models"	

Moderator

Dr. Ajay Agrawal
Peter Munk Professor of Entrepreneurship
Rotman School of Management
University of Toronto (Canada)

Panelists

Ms. Christina Chase
Entrepreneur in Residence
The Martin Trust Center for MIT
Entrepreneurship (USA)

Mr. Michael Kirkup
Director
Velocity
University of Waterloo (Canada)

Mr. Alan Lysne
Managing Director
Ryerson Futures Inc. (Canada)

Ms. Lindsey Marshall Gray
Director
NYU Entrepreneurial Institute (USA)

12:00 pm	**NETWORKING LUNCH**	*Salon Jacques-Cartier*

Time	Event	Venue
1:30 pm	**BREAKOUT SESSIONS**	

GROUP 1: "How do changes in the early stage environment affect the evolution of venture capital models? How can public policies find a balance in the support they provide to early vs. later stage financing?"

Moderator

Dr. Thomas Hellmann
Professor of Entrepreneurship and Innovation
Saïd Business School
Oxford University (UK)

GROUP 2: "How do university innovation initiatives fit into the broader early stage financing environment"

Moderator

Dr. Ajay Agrawal
Peter Munk Professor of Entrepreneurship
Rotman School of Management
University of Toronto (Canada)

GROUP 3: "Which LP funding models are working? What will it take to get the interest of institutional investors into VC? Can VCs instead get funded from alternative LPs, such as corporates?"

Moderator

Mr. Neal Hill
Vice President, Fund of Funds
Business Development Bank of Canada (Canada)

2:45 pm	**NETWORKING BREAK**	*Salon Rose*

Time	Event	Venue
3:15 pm	**SECOND PANEL: "Institutional investors' views on the financing of innovation"**	

Moderator

Ms. Luba Nikulina
Global Head of Manager Research
Towers Watson (London, UK)

Panelists

Ms. Michele Cucullu
Director, Private Equity
University of California (USA)

Mr. David Goerz
Executive Vice President, Investment Strategy and Risk Management
Alberta Investment Management Corporation (Canada)

Ms. Nicole Musicco
Vice President, Funds & Co-Investments
Teachers' Private Capital (Canada)

Time	Event	Venue
4:15 pm	**THIRD PANEL:"The Taiwanese model to link research institutions, large corporations, financing instruments to create new startups"**	
	Panelist	
	 **Mr. Herb Lin** President Industrial Technology Investment Corporation – ITIC (Taiwan)	
	Interviewer	
	 **Ms. Franceska Banga** CEO New Zealand Venture Fund (NZ)	
5:00 pm	**CONCLUSION**	
	 **Dr. Thomas Hellmann** Professor of Entrepreneurship and Innovation Saïd Business School Oxford University (UK)	
5:15 – 7:00 pm	**CLOSING SESSION** **Networking cocktail**	*Salon Rose*

KEYNOTE PRESENTATION

KEYNOTE SPEAKER

Dr. Josh Lerner
Jacob H. Schiff Professor of Investment Banking
Harvard Business School

Josh Lerner is the Jacob H. Schiff Professor of Investment Banking at Harvard Business School, and chair of the Entrepreneurial Management unit. He graduated from Yale College with a special divisional major that combined physics with the history of technology. He worked for several years on issues concerning technological innovation and public policy at the Brookings Institution, for a public-private task force in Chicago, and on Capitol Hill. He then earned a Ph.D. from Harvard's Economics Department.

Much of his research focuses on the structure and role of venture capital and private equity organizations. (This research is collected in three books, The Venture Capital Cycle, The Money of Invention, and Boulevard of Broken Dreams.) He also examines policies on innovation and how they impact firm strategies. (That research is discussed in the books Innovation and Its Discontents, The Comingled Code, and the Architecture of Innovation.) He co-directs the National Bureau of Economic Research's Productivity, Innovation, and Entrepreneurship Program and serves as co-editor of their publication, Innovation Policy and the Economy.

He founded and runs the Private Capital Research Institute, a nonprofit devoted to encouraging access to data and research about venture capital and private equity. In the 1993-1994 academic year, he introduced an elective course for second-year MBAs. Over the past two decades, "Venture Capital and Private Equity" has consistently been one of the largest elective courses at Harvard Business School. (The course materials are collected in Venture Capital and Private Equity: A Casebook, now in its fifth edition, and the textbook Venture Capital, Private Equity, and the Financing of Entrepreneurship.) He also teaches a doctoral course on entrepreneurship and chairs the Owners-Presidents-Managers Program and executive courses on private equity.

Among other recognitions, he is the winner of the Swedish government's 2010 Global Entrepreneurship Research Award. He has recently been named one of the 100 most influential people in private equity over the past decade by Private Equity International magazine and one of the ten most influential academics in the institutional investing world by Asset International's Chief Investment Officer magazine. He currently serves as vice chair of the World Economic Forum's Global Agenda Council on the Future of Investing.

First Panel

FIRST PANEL

"Fostering Entrepreneurship within Universities"

Introduction

Accelerators such as Y-Combinator and Techstars have introduced a revolutionary model to attract, select, network, mentor and fund young tech entrepreneurs to a point where they claim that this new model is becoming the basis for the next generation of business schools, in which learning will be achieved by doing rather than by business cases.

Many leading universities have received the message and are importing this model within the university, while building on their own competitive advantages: deep science, a wide range of talent and resources and an ability to leverage resources from the community. Their ambition is "to create a dynamic learning environment for university-affiliated entrepreneurs" (Creative Disruption Lab, Toronto), "to foster creativity and entrepreneurship while turning students' ideas into sustainable businesses" (Velocity, Waterloo), and "to accelerate the development of the university's top entrepreneurs through experiential education and collective intelligence" (Stanford StartX). In short, more and more leading universities are seeking to expand the benefits of the accelerator model beyond web-based and digital media companies.

This panel will explore the most innovative of these new accelerator models developed by universities such as MIT, NYU, Waterloo, Ryerson and Toronto, as well as their specific success factors, links with the rest of the financing chain and significant implications for next-generation public policies.

Panel's background information:

Part One: "University science and failures in the market for entrepreneurial judgment: economics of university accelerators – A case study"

Moderator:
Dr. Ajay Agrawal
Peter Munk Professor of Entrepreneurship
Rotman School of Management
University of Toronto (Canada)

Panelists:
Mr. Michael Helander
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Bionym Inc. (Canada)

Panelist:
Mr. Jesse Rodgers
Director
Creative Disruption Lab (Canada)

Presentation and moderator

Dr. Ajay Agrawal
Peter Munk Professor of Entrepreneurship
Rotman School of Management
University of Toronto (Canada)

Ajay Agrawal is the Peter Munk Professor of Entrepreneurship at the University of Toronto's Rotman School of Management, Research Associate at the National Bureau of Economic Research in Cambridge, MA, Co-Founder of The Next 36, and Founder of the Creative Destruction Lab at the University of Toronto.

Professor Agrawal teaches courses on business strategy, innovation, and entrepreneurship. He was recognized as "Professor of the Year" by the past seven consecutive graduating MBA classes. Professor Agrawal conducts research on the economics of innovation and creativity. He has presented this work at a variety of institutions including Harvard, MIT, Stanford, Berkeley, London Business School, Wharton, London School of Economics, Industry Canada and the Federal Reserve Bank.

Professor Agrawal advises firms and governments in fields related to innovation and strategy and has testified as an expert witness.

Panelist

Mr. Michael Helander
Co-founder and President
OTI Lumionics Inc. (Canada)

Michael received a B.A.Sc. degree in Engineering Science and Ph.D. degree in Materials Science & Engineering from the University of Toronto. He has published 104 peer reviewed publications, 8 patents and 2 book chapters. He is a Visiting Scientist at the Xerox Research Centre of Canada and is a Governor General Gold Medal winner, Vanier Canada Graduate Scholar, and Chorafas Prize winner.

Michael is currently Co-founder and President of OTI Lumionics Inc., an advanced materials start-up company working on low cost manufacturing solutions for organic LED (OLED) lighting and displays.

Panelists

Mr. Karl Martin
Co-founder and CEO
Bionym Inc. (Canada)

Karl Martin is the Founder and CEO of Bionym, the makers of the Nymi authentication wristband.

Karl has a PhD in Electrical and Computer Engineering from the University of Toronto, with expertise in the areas of biometrics, cryptography, and privacy.

He has appeared in media outlets across the globe, including The New York Times, BBC, Wired, Forbes, The Economist, and CNBC. He is also an active volunteer in the IEEE, serving as Toronto Section Vice-Chair.

Mr. Jesse Rodgers
Director
Creative Disruption Lab (Canada)

Jesse Rodgers is the Director of Creative Destruction Lab and has been in education and technology for last 15 years.

Prior to founding TribeHR (acquired by NetSuite in 2013), Jesse was Director and pioneer of the VeloCity program at the University of Waterloo.

Jesse holds a M.Sc University of Liverpool and a B.A. from the University of Waterloo.

FIRST PANEL

"Fostering Entrepreneurship within Universities"

Part two: "Contrasting models"

Moderator:

Dr. Ajay Agrawal
Peter Munk Professor of Entrepreneurship
Rotman School of Management
University of Toronto (Canada)

Panelists:

Ms. Christina Chase
Entrepreneur in Residence
The Martin Trust Center for MIT
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Mr. Michael Kirkup
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Moderator

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Rotman School of Management
University of Toronto (Canada)

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Professor Agrawal advises firms and governments in fields related to innovation and strategy and has testified as an expert witness.

Panelist

Ms. Christina Chase
Entrepreneur in Residence
The Martin Trust Center for MIT
Entrepreneurship (USA)

Christina Chase is an Entrepreneur in Residence at the Martin Trust Center for MIT Entrepreneurship, a Lecturer at the MIT Sloan School of Management, and the Academic Advisor for MIT's Department of Mechanical Engineering's Entrepreneurship Track.

Christina has helped hundreds of teams go from concept to company. She was recently named by Mashable as one of the 15 People Shaping Boston's Tech Scene. At MIT's School of Engineering, Christina teaches the largest undergraduate entrepreneurship class, Entrepreneurship in Engineering: The Founder's Journey, in the Department of Electrical Engineering and Computer Science. She also co-teaches Applications in Advanced Entrepreneurial Techniques, for advanced MIT startup teams, and Entrepreneurial Product Development and Marketing. In addition to these classes, she guest lectures in Design of Medical Devices, Precision Machine Design, and the Material Science and Engineering capstone design course.

Christina is an entrepreneur with a track record of success in a several industries, starting her first company when she was 18 years old. Most recently she was the CEO and co-founder of Firehoze, an education technology company that focused on online education that involved over a hundred instructors from the most prestigious universities. Prior to that, she worked with the founding team of the healthcare IT startup, Casenet, to build and run the marketing and business development division, where she positioned the company as the industry leader. At the photonics company, Labsphere, Christina ran the Materials and Coating division where, in under a year, she tripled her division's revenue and led the group to file three key patents. She has also worked at Dartmouth College's Entrepreneurial Network to help launch startups that commercialized Dartmouth College's intellectual property portfolio. At HP, Christina managed marketing for the newly formed OEM data storage division and changed the way HP thought about OEM marketing. The division grew by $750 million in a year. Christina is a Techstars mentor and serves on the Board of the MIT Enterprise Forum, the SXSW Accelerator Advisory Board and the SXSW V2V Advisory Board. In 2013, she was named one of the 25 Most Influential Women in the Boston Tech Community.

Panelists

Mr. Michael Kirkup
Director
Velocity
University of Waterloo (Canada)

Mike Kirkup is Director of Velocity, the University of Waterloo's world-renowned startup program. Mike joined the Velocity team in 2012 to help foster entrepreneurship throughout the University and beyond. Velocity has thrived under Mike's leadership with the successful launches of BufferBox, MappedIn and Thalmic Labs, to name a few. Mike is also spearheading an accelerated expansion of the program. By the end of 2014, the number of startups headquartered at Velocity and the amount of free workspace available to emerging businesses will have more than doubled that of a year ago. Mike understands both the creative and commercial paths to building successful businesses. For over a decade, he mentored hundreds of startups focused on developing mobile applications. His approachable demeanor and deep understanding of entrepreneurial culture and startup best practices have made him a notable influencer within the global startup community.

As a student, Mike spent several years on the University of Waterloo's campus, completing an undergraduate degree in Math and a Masters in Management of Technology.

Mr. Alan Lysne
Managing Director
Ryerson Futures Inc. (Canada)

Alan has been a co-founder, CEO, CTO, and COO of a number of technology businesses, and has been working with startups for well over a decade.

Alan was the CEO of a venture-backed mobile company that was acquired by Grapple Mobile, now Monitise PLC. After the acquisition, he served as COO and led the Toronto office, with a focus on business development and the technology platform. Prior to that, Alan was co-founder and CTO of Davinci Technologies that was acquired by CSG Systems (now Comverse Technology) where Alan served as an Executive Director and led a global team in the U.S., Canada, France, India and China.

Alan has an undergraduate degree in Electrical Engineering from Queen's University.

Panelist

Ms. Lindsey Marshall Gray
Director
NYU Entrepreneurial Institute (USA)

Lindsey Gray is the Director of the NYU Entrepreneurial Institute, where she develops educational programs and events to inspire, educate, connect, and accelerate entrepreneurs across NYU. Lindsey is also a member of the Teaching Team for the National Science Foundation's (NSF) Innovation Corps (I-Corps) program.

Prior to joining NYU, Lindsey worked for Innosight, an innovation firm founded by Clayton Christensen where she worked with Fortune 100 companies to help them identify strategic growth opportunities and build and invest in new businesses. She has worked with companies across a wide range of industries, and has helped clients establish a number of new high growth ventures. Before joining Innosight, Lindsey was a Director for the marketing analytics consulting firm, Kantar Retail, where she helped develop and sell new technology solutions for the consumer packaged goods industry. Lindsey also worked at CVS /Caremark in the pharmacy retailer's strategic product development group.

Lindsey received a Master of Business Administration from Harvard Business School and a Bachelor of Arts magna cum laude from Connecticut College.

CREATIVE DESTRUCTION LAB

YEAR IN REVIEW 2014

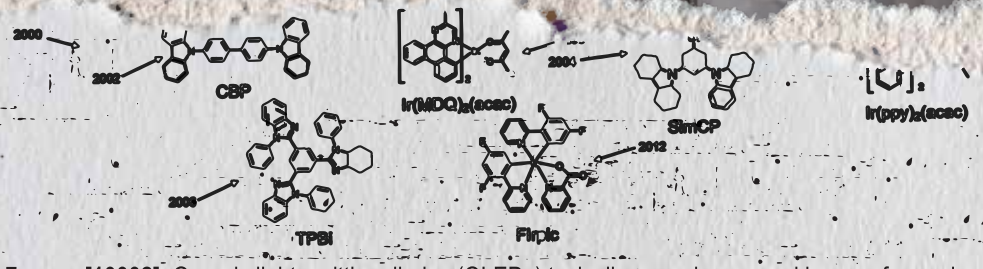
Appproved for use through 01/31/2104 OMB 0651-0032
U.S. Patent and Trademark Office; U.S DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act. of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number.

PROVISIONAL APPLICATION FOR PATENT COVER SHEET — Page 1of 2

This is a request for filing PROVISIONAL APPLICATION FOR PATENT under 37 CFR 1.63(c).

Confirmation Number: 1073

Title of Invention: Organic Electorluminescent ice with Multilple Phosphorescent Emitter



7 **[10002]** Organic light emitting diodes (OLEDs) typically comprise several layers of organic
8 material sandwiched between conductive thin film electrodes, at least one of the organic layers
9 being electroluminescent. When a voltage is applied to the electrodes, holes and electrons are
10 injected from the anode and cathode, respectively. The holes and electrons migrate from the

Rotman School of Management
UNIVERSITY OF TORONTO

Rotman

FLYING TO NEW HEIGHTS/

The G7 has... a wonderful diversity. The insights the Fellows bring and the ability to articulate them... I cannot tell you how valuable that is. They are helping founders fly to heights they have not imagined.

Joseph L. Rotman

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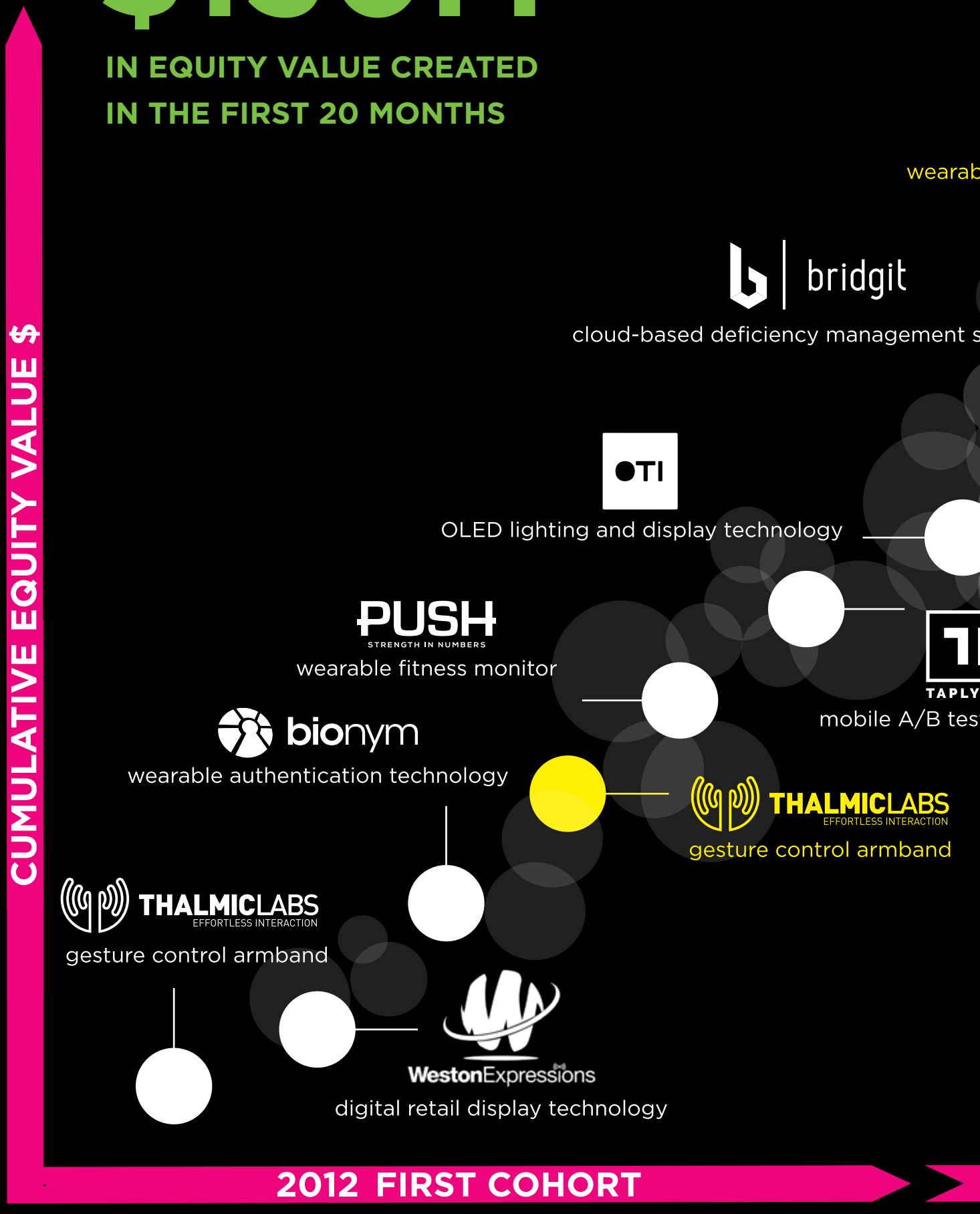
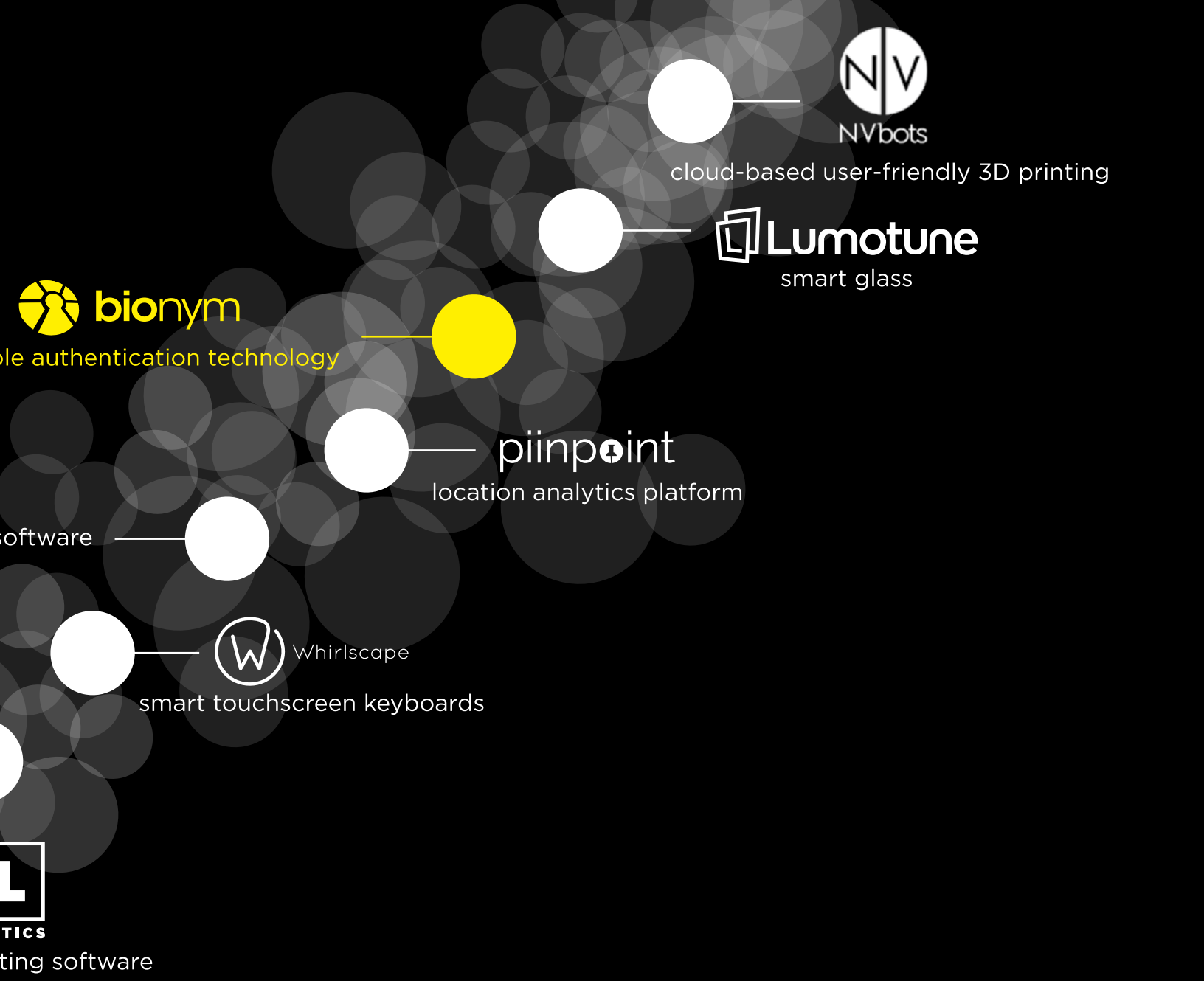
$130M

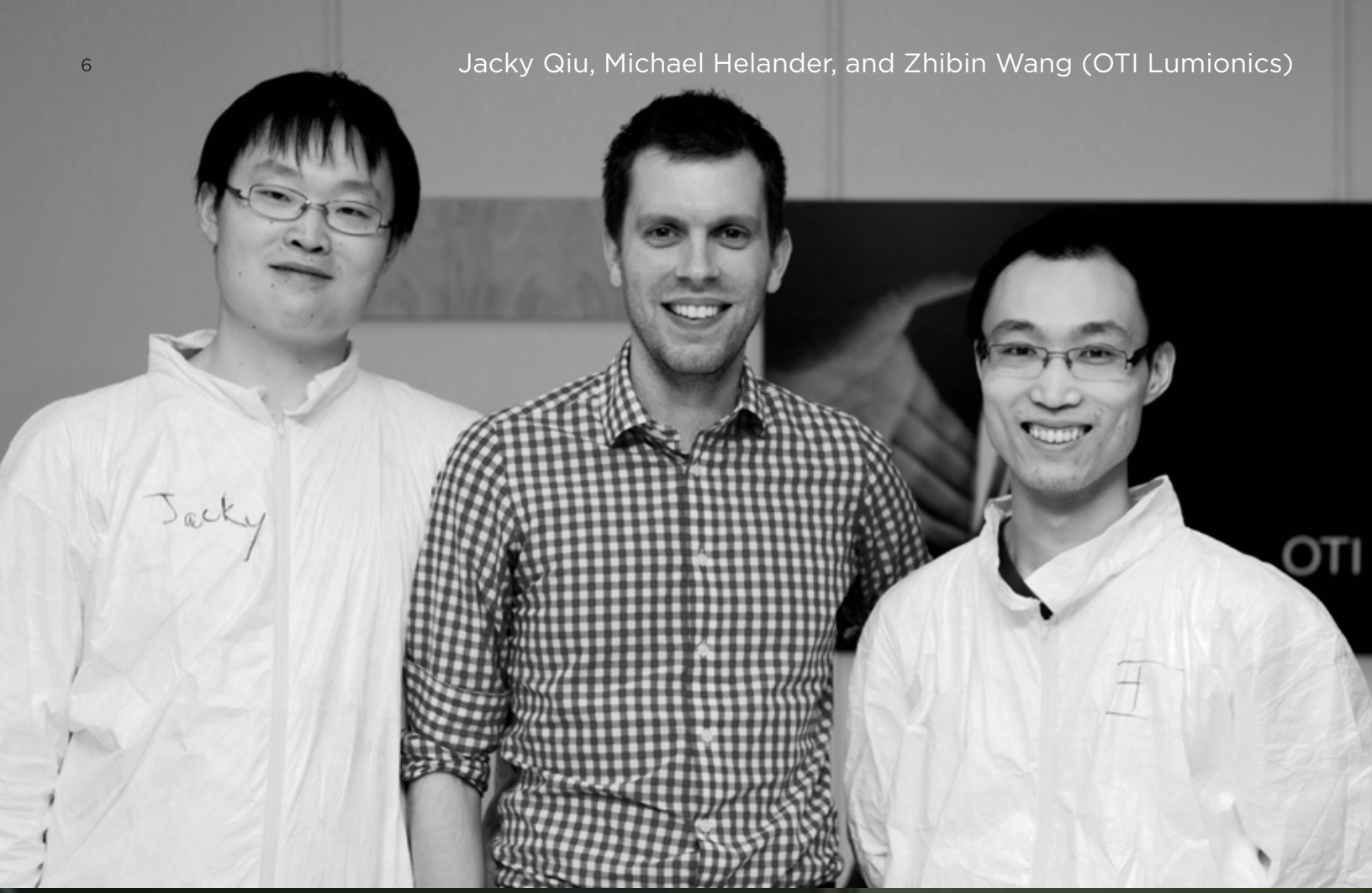
IN EQUITY VALUE CREATED IN THE FIRST 20 MONTHS





2013 SECOND COHORT

* We estimate a valuation of 4X capital raised for unpriced rounds (i.e., convertible notes).



Jacky Qiu, Michael Helander, and Zhibin Wang (OTI Lumionics)

Karl Martin (Bionym)

CDL CASE STUDIES/

Bionym and **OTI Lumionics** are two companies developing very different technologies but which have remarkably similar stories. OTI is revolutionizing organic LED manufacturing, while Bionym is changing the way we interact with our surroundings through wearable biometric authentication. Both ventures are founded by teams of PhDs, both initially tried to license their inventions to large corporations, and both entered the CDL running on fumes. The Lab helped each company's founders transform their strategies to focus on building products rather than licensing the right to use their embryonic technologies. Both companies subsequently went on to raise seed rounds in excess of $1 million led by G7 Fellows.

BIONYM/

MAKING IDENTITY EASY

Bionym co-founders Karl Martin and Foteini Agrafioti graduated from the first cohort of the Creative Destruction Lab in June 2013 with the ambitious goal to transform the way people interact with devices and services using a wristband called the Nymi that recognizes its wearer's unique cardiac rhythm.

One year later, Bionym employs over 30 staff, has closed a $14m Series A financing round, and has moved into a new office occupying the entire floor of a downtown Toronto office building.

Interview with CEO Karl Martin

Where did the science behind the Nymi come from?

Our technology emerged from research on biometric authentication and electrocardiogram (ECG) recognition at the University of Toronto's Department of Electrical and Computer Engineering. The ECG technology has unique characteristics in that it's a biometric that you don't leave around (like a fingerprint), so it's very closely tied to the body.

While we certainly weren't the only ones looking into ECG recognition, other research in this field used methods that didn't hold up when you actually put them out in the real world. These other methods only worked in a very controlled environment if signals were very clean and without noise. But the algorithms used in our technology had characteristics that made them more robust to the real world.

We benefited from the University of Toronto being a very research-oriented academic institution with a lot of curiosity-driven research. You wouldn't necessarily expect this kind of technology to come out of a private lab, because private labs have more specific mandates. Technologies like ours tend to come up in more curiosity driven research, and I think that's the point. When it's deep science, it's often not application-driven initially; it's curiosity driven.

How did you end up starting a company?

When I started grad school, I did so thinking I was going to be an academic. It was about midway through my PhD that several things converged to change that. One was that the actual practicalities of being an academic started to become less attractive. I love to teach and create things but the overhead of grant writing and university bureaucracy was unappealing.

> "**Our technology emerged** from research on biometric authentication and ECG recognition."

At the same time, I had the opportunity to work on a lot of industrial research contracts during my PhD, and it was when my work had this connection to real-world problems that I found myself most motivated.

Foteini and I started the company two years prior to joining the CDL with the basic idea that we would license the technology. Actually, we had a few technologies and no shortage of companies coming to us and showing interest in licensing them. But even after a couple of years, we were still very much in fishing mode, trying to find the right licensee. We had a patent and had hired a single staff member, but we weren't really focused on nurturing any one technology, and we were spread across too many of them.

How did the Creative Destruction Lab help?

When we applied to the CDL, it was the first cohort. We didn't really know what it was, but we were at a stage of the business where we were willing to try anything.

The core thing that happened during the program was that we made a major pivot to go from a licensing business model to making and selling this wristband that serves as a universal authentication device. We had lunch one day with two of the G7 Fellows, Nigel Stokes and Dennis Bennie, to approach them on the topic of fundraising. Before we even got to talk about it, Dennis told us he thought our business model was awful and that we had to do something different.

It was that gentle slap in the face that led us to make the hard decision that we weren't going to try to license the technology anymore. It was bold for us because that's all we had considered doing until then and we still had several companies negotiating with us. But we made this U-turn anyway, and it was very empowering because there was no halfway. We were forced to ask: What are we really doing? Why does our company exist?

This led us to decide to make a complete product, and then over the course of a week we designed the concept of the Nymi. It happened very fast, but it didn't happen in a vacuum; there was all of our learning from the prior two years to draw on. We designed the product at the concept level, and everything has gone from there. We knew in our heads what was possible, and now we just had to go out and build it. The funny thing is that on a conceptual level, the product we came up with in that week has stayed pretty much the same ever since; we've just had to build it and all of its components.

Following our pivot, we raised a seed round largely from the G7. Of the $1.4 million we raised, $1 million of that was from G7 Fellows, which is obviously a pretty significant commitment. But two G7 that participated in the seed round also became board members, and we stay in close contact with others for input and even to explore business development deals with other companies they are involved in.

How has the technology evolved over the past two years since joining the CDL?

What's most interesting isn't how the core technology of ECG recognition has evolved but how everything we've had to build to make it work as a consumer product in the form of a wristband has developed. The ECG technology now is an important but only a small part of the product.

In the last year, we have had to build a lot of technologies, which have become equally if not more valuable than the original ECG recognition. The CDL and the G7 pushed us to take this deep dive, and that's led us to solve some very challenging technological problems, making us that much more valuable as a company.

So for example, a lot of the intellectual property we are building now is really at the system level. We are answering questions like how to design a low-power device that communicates with multiple devices seamlessly and keeps them unlocked and provides a persistent identity. It's not straightforward, and there is a lot of intellectual property involved in the design of this kind of system.

What makes the CDL unique?

I think the CDL is a great place for science-based startups in particular because it surrounds you with people and content that teach you how to build something massive. I think a lot of grad students or scientists have this sense that the types of blue-sky research results they come up with in the lab could have very big applications in the real world, but they don't know how to get there.

The other thing is that an appreciation for science is a part of the CDL's DNA. The staff and G7 Fellows appreciate the nature of research and what it means. As a science-based startup, you can go to other places, but without that appreciation, the input or advice won't be as relevant and not as big of an effort will be made to adapt this input to your technology or company.

Another thing is that there are people at the CDL, the G7 Fellows, who have built significant companies, and that's pretty unique. There is nowhere else you can go to get the kind of input they can give.

By being connected to a business school, the CDL also enables you to think about strategy for your business on a whole different level than you would otherwise or compared to other incubators or accelerators. So I think anybody that went through the program that has now achieved some level of success can point to the depth of strategy work, especially if you don't come from a business background. Calibre matters here too. If it was any run-of-the-mill business school, I don't think it would work. The CDL is drawing upon the best of the best when it comes to strategy, and this is relevant to startups. At the end of the day, the entrepreneur doesn't have time for anything that's not relevant, and the CDL has been built to be highly relevant.

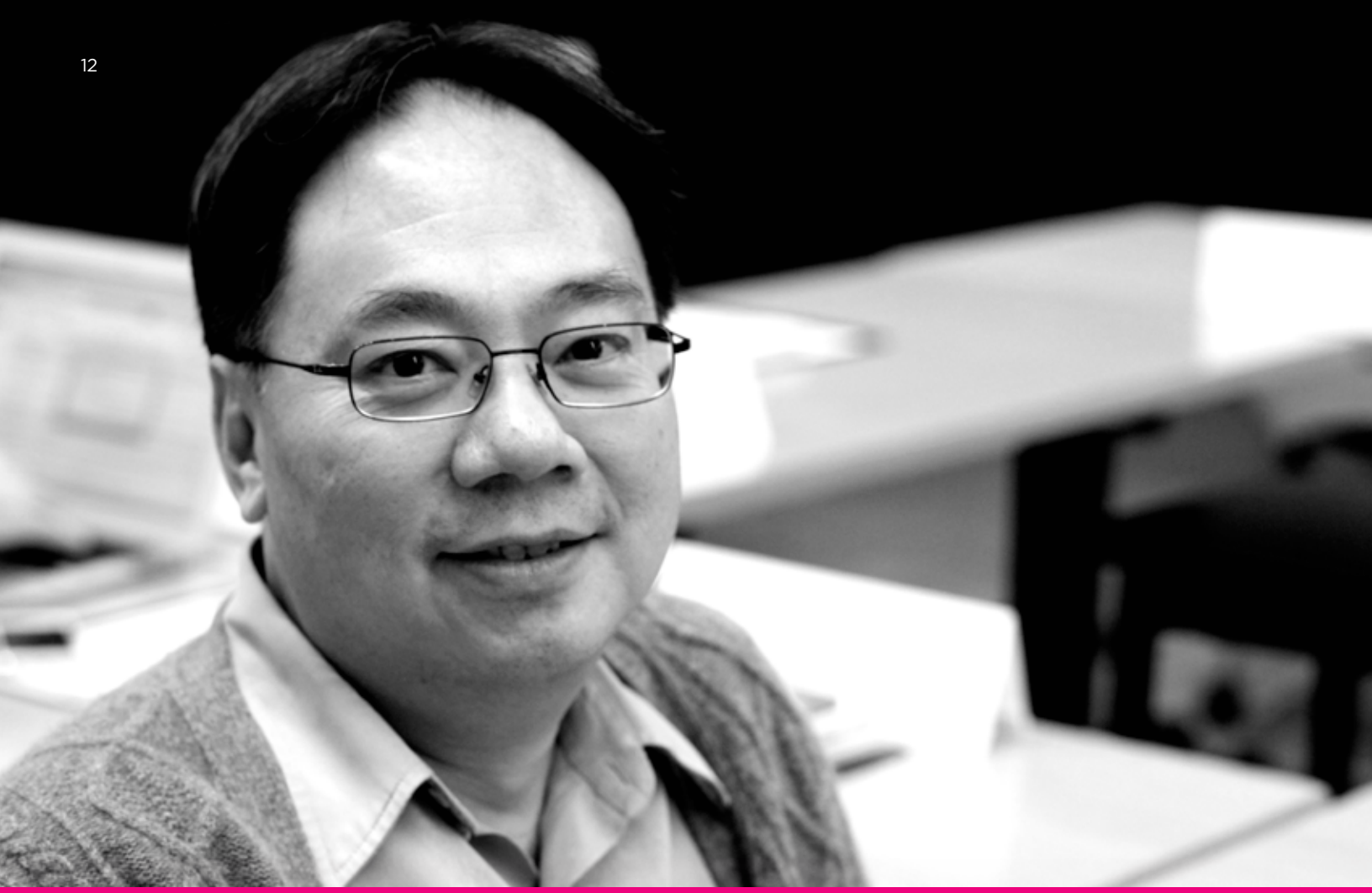
Next Steps

Right now, we are very focused on getting the product out, and we are ramping up manufacturing. Longer term, we are focused on building a huge company on this platform and exploring how we can be successful. And it won't be because of any one technology or piece of hardware. It will be because what we are doing as a company is making identity easy for a number of applications and different kinds of interactions that people have with services. The hardware and the technology are vehicles to enable that, but what we are building our business on is this massive concept of the last mile of connection between a service and a user or between a device and a user and making that a trusted connection. We are opening up new and different things you can do as a retailer, a payment provider, or a hospitality service, in terms of how can you create new experiences for customers if identity becomes really easy. Our goal is to make identity easy, and then so many things

can come out of that. It's a huge problem we are trying to solve, but if we hit it, it will have an enormous impact. That's what we're gunning for.

We also continue to be in close contact with the CDL and the G7. I'm still very involved with CDL events. Part of that is to give back. I personally feel like I've learned so much that I can't keep it to myself; I need to share this. The other part is just to support the CDL however I can, because we wouldn't be here, we wouldn't have made this pivot or figured out how to get this far, without the CDL. The CDL has become a central part of my network, and so I want to be involved in any way I can. As an entrepreneur, you realize that your network is hugely valuable. Whether it be for recruiting or business development or just new ideas, staying fresh and knowing what's out there is key, and the CDL is a core part of that.

> "**The CDL is a great place** for science-based startups."



POTENTIAL TO SUCCEED

I think the Lab has done a great job helping early-stage startup companies like OTI Lumionics. OTI's founders came to the Lab as researchers. They were very talented and energetic but had little experience in business. Today, they have an achievable business plan and, while work still needs to be done, there is a lot of potential for their team and their technology to succeed.

Lee Lau, G7 Fellow and Founder of ATI Technologies


OTI Lumionics
OTI Lumionics
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Lumionics

OTI LUMIONICS/

REINVENTING THE LIGHT BULB

In December 2012, Michael Helander, Zhibin Wang, and Jacky Qiu, three PhD engineering students at the University of Toronto, were looking for office space for their new startup. As they walked the halls of the historic building, named after Nobel laureate Sir Frederick Banting, they passed an expansive, 3,300-square-foot, fully modernized lab space en route to the much smaller 249-square-foot space they would ultimately lease. "I remember the leasing agent telling us that we'd never need the space of the larger room. And we said, 'Yeah, you're right'" recalls Helander.

Eighteen-months later, the last eight of which were spent as part of the Creative Destruction Lab's second cohort, Helander and his co-founders moved into the space they weren't expected to ever need, having secured nearly $1.5 million in financing in a seed round led by G7 Fellow Lee Lau.

Interview with President & CEO Michael Helander

What is OTI Lumionics?

We build manufacturing solutions for organic light-emitting diode (OLED) lighting and displays that are paper-thin, lightweight, flexible, cheap, and environmentally friendly to dispose of.

What is the ideal application?

For us, the most exciting applications aren't the sexy ones. Our vision for products built with our technologies is more practical. When it comes to lighting, there's always been this trade-off between having a good quality of light or having energy efficiency. You end up with fluorescent tubes or LEDs that are cold and harsh or with a single bright spot of light that use a lot of energy. But imagine if your whole ceiling or part of a wall could be a source of higher quality, softer, and more natural light.

Lighting is something we take for granted. It still accounts for a huge amount of electricity usage, and it actually has a lot of health impacts that we're just now starting to realize, like how it affects sleep patterns or how its color affects the circadian rhythm. Without lighting, there would be no modern society; it's what started the whole industrial revolution. So altering a paradigm that hasn't changed in 135 years is what gets us excited.

> "**We build manufacturing solutions** for organic light-emitting diode lighting."

Where did the science behind OTI Lumionics come from?

We were a bunch of grad students doing our PhDs in Materials Science & Engineering, literally a hundred metres down the street from here. We were working in a field called organic electronics with the idea of taking carbon-based dyes and pigments that are found in things like clothing and printer ink, taking similar molecules to those, making thin layers of them, and building electronics and specifically electronics that generate light.

It was an academic challenge for us to prove that the industry was wrong in saying that our approach to simplified manufacturing was not possible. We started publishing a lot and then, as we made progress, we started getting interest from large electronics companies that wanted to buy or license the technologies we were developing.

How did you end up starting a company?

At first, licensing seemed like a great deal for us; we were all ready to be professors. When we started the company, it was just to facilitate licensing negotiations with these big companies who wanted our intellectual property. We were being offered very good money for what were still very embryonic ideas. At that point, I really saw commercialization as just another line to add to my academic CV.

But it quickly became apparent that a lot of these companies were interested in the technologies just to pad their patent portfolios and not necessarily to use or develop them further. We started realizing that if they were offering so much money, there must be more value here than they were letting on. At the same time, we weren't happy with the idea that we'd be contributing to the problem of Canadian research being shipped abroad to be commercialized with little value added to our own national economy. So as we neared graduation, we decided to make a go of it as a startup. We wanted to reinvent the whole paradigm of lighting.

How did the Creative Destruction Lab help?

On the practical side, there are a few good examples I can point to. We met the person who would eventually become our COO at last year's DemoCamp even before we officially got into the program. And in our first meeting with the G7 Fellows, we came in ready to discuss a term sheet we'd been offered from a small, local VC Fund. The G7 told us it was a terrible deal and not to take it, and we didn't.

We've learned a lot in terms of just focusing on one or two key problems or milestones and honing in on delivery. We've worked on really distilling all of the technical aspects of our business into their simplest form. Then there are all the skills around fundraising, managing a team, and the day-to-day operation of a company.

By far, the most important thing has been building our relationship with G7 Fellow Lee Lau. His wealth of knowledge and experience has helped us overcome major challenges, and his investment gave us a lot of credibility in the eyes of others who might have trouble understanding our field. We owe a lot of our success to Lee Lau believing in our team and supporting our vision.

What makes the CDL unique?

There are two or three significant things that make CDL different. One is that the original purpose was to help commercialize technologies like ours. It was part of the original mandate to support all of these grad students doing great research and innovating in Canada but not taking it anywhere.

Another thing is that the CDL is located in a business school. It's popular to believe that business schools aren't the right place for entrepreneurs to thrive, but the fact that the CDL is located in the Rotman School but still puts first the venture founders - most of whom are not MBAs - really makes it the perfect compromise. Ventures benefit by leveraging the intellectual capital of some of the country's foremost business experts and also by having access to a continuous supply of hungry MBAs. At the same time, MBAs who may have been destined to become consultants or managers in large firms get the chance to work on building a real business while they complete their degrees.

The other key element is that a number of the G7 are not only successful entrepreneurs but also significant investors. They can put on their investor hats and say, "Okay, I understand what it's like from your perspective as an entrepreneur, but here is what investors are not going to like about it."

What's next?

We are in the process of building our pilot facility and hiring staff with the ultimate goal of proving our technology and then building a manufacturing plant somewhere in southern Ontario.

We also are still in close contact with the CDL and the G7. We attend CDL events, and we are still involved with some of the MBA students and other venture founders. We wouldn't be here without the support of the CDL and its whole network; we feel incredibly lucky to be part of that family. It has benefitted us so much that it's just the right thing to do now to give back to the program and pass it on. I look forward to being involved in helping future cohorts achieve their full potential.

G7 FELLOWS/

Dennis Bennie

Founder, Delrina

Daniel Debow

Founder, Rypple

John Francis

Former CEO, Trader Media

Nick Koudas

Founder, Sysomos

Lee Lau

Founder, ATI

Ted Livingston

Founder, Kik

Jevon MacDonald

Founder, GoInstant

Geordie Rose

Founder, D-Wave

Nigel Stokes

Founder, DataMirror

WELCOME

G7 FELLOWS/

In 2014-2015, the Lab will welcome three new G7 Fellows and two new G7 Associates.

G7 Fellows

Tony Lacavera

Tony founded WIND Mobile in 2008, raised $1.5b in capital, and built the company into the leading facilities-based challenger wireless company in Canada. WIND Mobile has grown from start-up in 2008 to $350m revenue in 2014 and has 1,200 employees, an advanced wireless network covering over 14 million people, and a retail network of 300 stores and dealers.

David Ossip

David is Ceridian HCM's Chief Executive Officer and the driving force behind the innovation, vision and leadership of the company. Dayforce, a highly successful SaaS-based company founded by David, was acquired by Ceridian in 2012. David previously founded Workbrain, where he served as CEO and President and was responsible for the company's overall product and market direction. David has been recognized with many awards for leadership, including: Canada's Best 50 Managed Companies, Ernst and Young Entrepreneur of the Year Award, Arthur Kroeger College Award for Management, and a Special Citation for Technology Innovation. In 2004, he was named to Canada's Top 40 under 40. David holds an MBA from Harvard Business School.

Michael Serbinis

Michael is a serial entrepreneur and angel investor. Michael founded Kobo, a global eReading company, and sold it to Japanese internet giant Rakuten for $315m in 2012. Prior to Kobo, Michael developed internet-routing technology at Microsoft, search technology at Zip2 (sold to Altavista for $300m), and messaging systems at Critical Path, as well as founded cloud storage pioneer DocSpace (sold for $568m in 2000). Today, he is the founder of the Everlong Project, a new digital health startup, CEO of Three Angels Capital, and a Board Director of the Perimeter Institute for Theoretical Physics.

Thank You

We extend thanks on behalf of the Lab and the Rotman School to Lee Lau, Nigel Stokes, and Dennis Bennie. Each served on the inaugural G7 and then recommitted for a second term last year. The Lab grew significantly under their leadership. We are grateful for their work. Thank you Lee, Nigel, and Dennis. You will be missed.

G7 Associates

Johann Koss

In 2000, Johann founded Right to Play, a not-for-profit that now employs over 600 international staff and oversees more than 13,500 volunteer coaches across 20 countries affected by war, poverty, and disease in Africa, Asia, the Middle East, and South America. Johann is also a four-time Olympic gold medalist in speed skating.

Boris Wertz

Boris founded JustBooks in 1999. He sold it to AbeBooks, which was subsequently acquired by Amazon. In 2012, Boris founded Version One Ventures, an early-stage fund investing in consumer internet, SaaS, and mobile. In 2014, Boris joined Andreessen Horowitz as a Board Partner.

Tony Lacavera
Founder, WIND Mobile

David Ossip
Founder, Dayforce

Michael Serbinis
Founder, Kobo

Johann Koss
Founder, Right to Play

Boris Wertz
Founder, Version One Ventures

ABOUT THE LAB/

Two ambitious goals

The Creative Destruction Lab is a program for massively scalable ventures. The Lab provides a unique style of milestone-based mentoring with the goal of maximizing equity value creation. Our first goal is to generate $1 billion in equity value in the ventures that graduate from the Lab by 2022. The process of pursuing our first goal sets the stage for our second, which is to provide a transformational experience for students at the Rotman School of Management. The CDL courses offer a significant pedagogical innovation in graduate management education by replacing the traditional case study method with experiential learning ("learning-by-doing") during the process of rapid equity value creation.

Who we support

Each year, the Lab admits 25 ventures. The Lab considers all applicants but is particularly suited to early-stage, science-based technology companies, especially those with links to research conducted in Canadian university labs (this year, the Lab accepted one venture from MIT). The deadline for applications is in late August, and the nine-month program runs from October to June.

Companies fit for survival – the role of milestones

A cornerstone of the Lab is its focus on business and technical milestones. The G7 Fellows carefully design milestones to increase ventures' chances of success. Meetings with the G7 take place roughly every eight weeks with the main objective of assessing progress to date and setting new milestones. Tenacious commitment to achieving the milestones is of paramount importance for each venture admitted to the Lab. Ventures that are not fully committed to achieving their milestones are cut periodically throughout the program, such that less than half the ventures admitted in September still remain in June. While more than 50% of ventures may be dropped from G7 meetings over the program's duration, these companies remain part of the CDL community and continue to be invited to the Lab's networking and training events. Ventures that consistently achieve their milestones often attract investment capital from G7 Fellows.

Professor Ajay Agrawal, Founder

Jesse Rodgers, Director


DemoCampToronto
PulseChase


DemoCampToronto
BeMused
Network


DemoCampToronto

DEMOCAMP 2014/

On May 6, 2014, more than 500 attendees from industry, government, science, and the University of Toronto's student population joined us at the Rotman School for the third installment of the Lab's marquee event: DemoCamp 2014.

Venture founders and alumni of the CDL MBA course shared their stories, and aspiring inventors and entrepreneurs hoping to be admitted to the next cohort presented their technologies while describing their dreams for improving the world.

MBA COURSE/

In May 2014, 25 Rotman MBA students completed the inaugural Creative Destruction Lab course. Students were immersed in the Lab's activities and exposed to the challenges and opportunities faced by the Lab's startups as well as the unique insights and knowledge of the G7. At every step of the ventures' progression through the Lab program, the inaugural class was there to watch, listen, and most importantly contribute to the process of equity-value creation.

What began as a unique experiment to find a new way to teach the skills and knowledge of startup creation in a traditional MBA setting has now become an important part of the Rotman School's offering to attract some of the most compelling prospective MBAs.

An Innovation in Graduate Business Education

In September 2014, the Lab will welcome its second class of Rotman MBAs. The year-long course merges the traditional business school classroom with the Lab's activities to identify and help launch, finance, and manage entrepreneurial ventures. Working alongside G7 Fellows, venture founders, and the Lab team, students are given a unique chance to learn how to better evaluate and build early-stage technology businesses.

MBA students learn the nuances of working with startup founders and maximizing the value they add to entrepreneurial venture. Ventures benefit by learning how to effectively engage MBAs. Throughout this process, the Lab coordinates relationships, expectations, and outcomes to help each party derive the greatest possible benefit.

The Creative Destruction Lab course experience was transformational for many of the MBA students in the inaugural class.

This year Professor Joshua Gans will launch a second CDL course on "entrepreneurial strategy."

> "**The Creative Destruction Lab is itself a brilliant innovation, and the G7 is an incredible group.** It's been an eye opener for me to see how you bring your expertise and experience to bear in advising our students. It's a priceless contribution, and we want you to know how much we appreciate it. You are powerful role models, and we need more of those."
>
> **Professor Meric Gertler,**
> **President, University of Toronto**

Entrepreneurship is hard. At business schools they try to teach the science of it, but the question is: Does the art and the science come together? To see how decisions are made is an extremely unique experience for the MBAs in the course and something you can't get at most business schools.

Tiff Macklem,
Dean, Rotman School of Management

"This course has been without a doubt the most impactful and interesting learning experience I have had in my entire academic career... it was not until I returned to school and enrolled in the CDL course that I felt the excitement and passion that comes with a learning experience that inspires you."

Hayley Angus, MBA 2014

"This course has proven itself to be the single most important class I have taken... it is the most talked about class at the Rotman School."

Angus Campbell, MBA 2014

“My experience with the Creative Destruction Lab has been a transformative one. I came to Rotman with the intention of pursuing a high-achieving, yet more traditional career path... I am no longer bound by this mental constraint.”

Nicolas Mayer, MBA 2014

“This course has changed my career trajectory and left me with important insights that would have taken years to learn otherwise.”

Ammar Sabzwari, MBA 2014


Founder


Founder


Founder


Founder

VENTURES GRADUATING FROM THE 2013-2014 COHORT/

Taplytics
A native mobile A/B testing solution for app developers.

Push
The first fitness tracking device that measures strength.

Bridgit
A mobile and web communication platform for the construction industry.

OTI Lumionics
A low-cost manufacturing solution for organic light-emitting diodes (OLEDs).

Lumotune
A transparent, flexible, electronic display that can be placed on any surface and observed in any light setting.

Piinpoint
An online platform that uses machine learning to identify optimal new store locations while centralizing demographic, real estate, traffic, and municipal data.

Whirlscape
The developer of Minuum, a one-dimensional keyboard that enables typing on wearable devices and saves smartphone screen space.

Instant Chemistry
A firm that uses genetics-based algorithms for the assessment of human compatibility.

Kiwi Wearables
A smart accessory for your watch with motion control, notifications, and activity tracking.

NV Bots
The first cloud-controlled automated 3D printer company.

T-Bot
The first automated loose-leaf tea vending-machine company.

PARTNERS AND ADVISORY BOARD/

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Rotman School of Management
UNIVERSITY OF TORONTO

Rotman

ABOUT THE MIT GLOBAL FOUNDERS' SKILLS ACCELERATOR

The MIT Global Founders' Skills Accelerator (MIT GFSA) is the premier university student accelerator in the world, offering a capstone educational program to students to round out their multi-dimensional, entrepreneurial experience.

We take the best teams from across all of MIT's schools as well as top student teams from select global university partners. Since we believe that the best entrepreneurs approach their ventures with a global mindset, the MIT GFSA allows student entrepreneurs from around the world to work next to, collaborate with, and learn from one another, ensuring a well-rounded, global perspective on new venture creation.

By participating in GFSA, student teams are put through a rigorous, educational summer-long startup accelerator, allowing them to make dedicated time for their startup and to learn by doing. GFSA takes great teams with an interesting idea or proof of concept and works with them to make significant progress toward identifying their beachhead market, building the right product, and securing initial customers or partners. By mentoring teams throughout the summer and working to help them hit escape velocity by Demo Day, GFSA is focused on creating impactful, innovation-driven startups led by MIT students who are seeking to change the world.

FOR ADDITIONAL INFORMATION, PLEASE VISIT HTTP://GFSA.MIT.EDU.

Ryerson Futures Inc.

Ryerson Futures Inc. (RFI) is a Founders First Accelerator program connected to the Digital Media Zone (DMZ) at Ryerson University. RFI is focused on assisting early stage technology companies as they grow and scale. RFI manages a fund, provides seed financing, advisory and business services and customer connections to select startups in exchange for an equity stake. RFI also works with corporate clients to assemble teams of entrepreneurial innovators to research, prototype, or pilot solutions to industry problems. Ryerson Futures is helping drive Canada's innovation economy at home, and around the world. Since 2010, RFI & the DMZ have incubated 130+ startups and raised in excess of $50 MM in funding. For more information, visit www.ryersonfutures.ca

The DMZ at Ryerson University is one of Canada's largest incubators and multidisciplinary co-working spaces for young entrepreneurs. Infused with the energy and resources of downtown Toronto, this hub of innovation, collaboration and commercialization is home to both startups and industry solution-providers. The DMZ leads the way in experiential learning and business success by creating a unique ecosystem of education and entrepreneurship. Emerging leaders fast-track their product launches and grow their companies in this supportive community by connecting with mentors, customers and each other. Since opening in April 2010, the DMZ has stimulated Canada's digital economy by incubating and accelerating startups and fostering the creation of more than 1400 jobs. For more information, visit www.ryerson.ca/dmz.

Recently, DMZ was ranked #1 university led start-up incubator in Canada, and #5 globally by the University Business Incubator Network.

About Velocity

Velocity is an entrepreneurship program at the University of Waterloo. The program aims to give students and alumni access to a learning-focused community of mentors and like-minded peers, resources and equipment, so they can turn their ideas into successful companies.

Velocity works with the University of Waterloo and Velocity alumni to fund and facilitate this not-for-profit discovery and incubation program for entrepreneurs. The program is focused on helping grow successful business without looking at equity in any of the companies as a revenue stream.

It is unique in its approach of offering peer networking, mentoring and resource opportunities to people at all stages of entrepreneurialism – whether someone is at the idea stage, the early building stage, the funding and prototyping stage, or into launch and commercialization.

To create this life cycle of entrepreneurship for the Velocity community, Velocity currently oversees six programs to engage and encourage entrepreneurs. Specific to students who have been bitten by the entrepreneur bug, Velocity offers three on-campus programs: Velocity Residence, Velocity Alpha and Velocity Science.

To ensure that the newest, most innovative ideas are brought to light and given their best chance of initial success, Velocity runs the Velocity Fund – three competitions per year that help student and graduate entrepreneurs fine-tune their pitching skills, understand the questions that potential investors would ask, and mature their product and business model.

For students and graduates who are ready to take their startups to the next level, Velocity has the Velocity Garage and Velocity Foundry, both located off-campus in the innovation district of Kitchener.

A bit more about Velocity Programs:

Velocity Residence

Students who are interested in launching a startup, passionate about entrepreneurship, or have a great idea can apply to be part of Velocity Residence. Students live in an entrepreneurial environment and are given access to the latest technologies and the opportunity to learn from a great network of mentors and fellow entrepreneurs. Velocity has seen teams form after they met in the Velocity Residence and we hear from our students that the connections they make are priceless.

Velocity Alpha

If there is a student with any kind of business idea, for any industry, Velocity wants to arm students with information and opportunities to take that idea and turn it into a viable startup. Velocity Alpha hosts networking events and entrepreneurial-focused sessions – from idea generation, to avoiding startup pitfalls, to customer discovery and market validation. There are panels with local business leaders and entrepreneurs and each weekly session or event builds upon the last to provide hands-on experience and real-world experience as students begin to launch their own businesses.

Velocity Science

Velocity Science is aimed at students interested in building life sciences or material sciences businesses. Velocity Science provides students with the resources needed for discovery and inspiration including high-tech equipment, technical resources, basic consumables and lab space, with 24-hour wet lab access, to ensure students can develop, test and implement their ideas. Velocity Science works with local experts, successful entrepreneurs, and faculty in the life sciences to give students access to meaningful coaching and mentoring.

Velocity Fund

Funding for very early stage companies is an important part of the support Velocity provides through the Velocity Fund. The Velocity Fund is a grant program for startups and aspiring entrepreneurs to win funding through competitions held three times per year. The following grants are available:

1. Velocity $25K – Velocity provides four $25,000 grants for the best companies who are current students or recent alumni who have graduated within the past year.

2. Velocity $10K Hardware – a $10,000 grant for the best hardware company who wins the Velocity Fund $25K.

3. Velocity $5K – Velocity awards three $5,000 grants for very early stage startups with the most innovative business, best pitch and people choice.

Velocity takes no equity and no intellectual property in return for the grant. The Velocity Fund was established in 2011 following a donation of $1 million by Kik founder and Velocity Residence alumnus Ted Livingston. In December 2013, Velocity received a donation from the founders of BufferBox, Mike McCauley, Jay Shah and Aditya Bali to encourage the creation of a hardware award given the additional costs to build successful hardware startups. In March 2014, Velocity received a donation of $1 million from renowned Waterloo Region angel investor Mike Stork.

Velocity Garage

The Velocity Garage is a 7,000 sq ft shared workspace for students and alumni who benefit from mentoring and free space to kickstart their companies. The Velocity Garage is located in the innovation district of Kitchener where over 100 startups now have their headquarters and workspaces. Sharing the Velocity Garage with like-minded entrepreneurs builds a network of support for these early stage companies. Businesses working out of the Velocity Garage are software and digital media startups, who are there to learn, collaborate and innovate.

Velocity Foundry

The Velocity Foundry, at 11,000 sq ft, is the newest Velocity workspace and provides equipment, connections and mentorship to hardware and life science startups to help them develop, build, test and launch their products. Successful entrepreneurs serve as mentors to the companies in the Velocity Foundry and teams are encouraged to collaborate, problem-solve and contribute back to the startup community by mentoring others.

Each of these unique initiatives supports Velocity's vision of developing an engaging community that fosters creativity and entrepreneurship while turning students' ideas into sustainable businesses. They also form the perfect complement to the environment at the University of Waterloo — a university that holds entrepreneurship as one of its key pillars — by equipping students with the knowledge and tools necessary to navigate the entrepreneurial space, supporting knowledge sharing among peers, providing access to a diverse network of mentors, and allowing students to maintain ownership of their intellectual property.

Building a Velocity Community

Bringing together a series of programs in the beginning life-cycle of a startup is key to Velocity's success in graduating businesses that have gone on to global success and renown. Some past graduates include Thalmic, a connected-wearbles business that is preparing for the global launch of its MYO arm band; Kik, a social messaging applications with more than 150 million users so far; PumpUp, a fitness social network and workout app; and Vidyard, a video analytics solution.

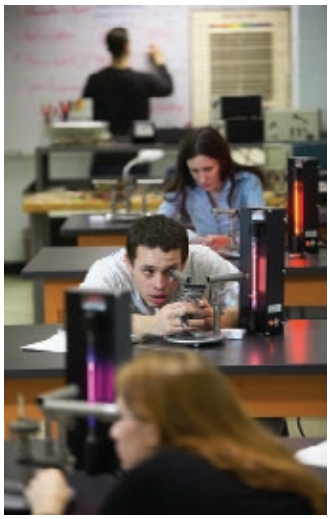
Graduates are encouraged to serve as mentors and to give back to the community by helping other businesses and supporting the local economy. Velocity's leadership team serve as coaches to the companies and students in the program and are selected for their experience with the local entrepreneur economy or their networks of local influencers and partners.

Velocity's focus on students and alumni, as well as its mix of on-campus and off-campus programs set it apart form other incubator programs and have made it a leader and example to other programs hoping to mirror its success.

NYU | Entrepreneurial Institute

Learn how to start a company based on your research or inventions

The NYU Entrepreneurial Institute offers programs, resources, and funding to help you get started!



© NYU Photo Bureau

University laboratories have been the birthplace of some of history's most innovative and game-changing startups. Universities have produced biotechnology, nanotechnology, software and electronics; giants such as Genentech, Cisco, Chiron and Google were all born out of university research.

There's an extraordinary potential for NYU research to create new, life-improving technologies, spark economic growth and solve society's most pressing problems. But doing so requires that we get NYU inventions out of the labs and into the market.

It takes a strong entrepreneurship community to grow a startup, and the NYU Entrepreneurial Institute actively works to build and support a strong entrepreneurial ecosystem, both within the University and with the broader NYC startup community. As a top research institution located in the business capital of the world, NYU provides innovators with the resources needed to transform their research and ideas into products and services in the global marketplace.

The NYU Entrepreneurial Institute helps startups start up.

At the NYU Entrepreneurial Institute we:

INSPIRE and encourage entrepreneurial behavior

EDUCATE and train students, researchers, and faculty in startup best practices

CONNECT entrepreneurs within the NYU community and to the broader NYC startup ecosystem

ACCELERATE and support growth of promising projects and teams

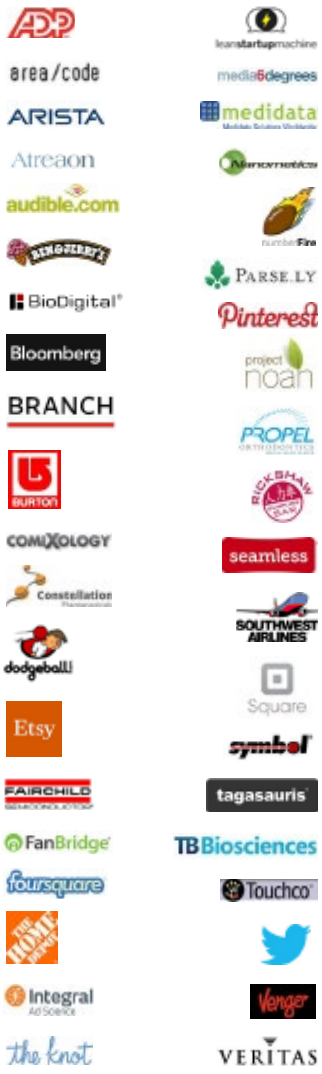
FUND early-stage venture growth by facilitating access to gap and seed capital

"Taking research or ideas into the market is a process that requires understanding the customer and their needs. The process of customer discovery has been an eye-opening experience for me as I look at the research I engage in with applications in mind. The entrepreneurship programs NYU provides have helped me understand the startup language and landscape to further advance the technologies I developed in the lab."

— Jin K. Montclare, Associate Professor Chemical and Biomolecular Engineering, Polytechnic Institute of New York University
Founder, LabLessons

"In order to succeed as a scientist running an academic laboratory one needs to understand and invoke entrepreneurial activities that include hiring personnel, raising research funds, and marketing one's discovery to both the academic and business communities. Through the programs and initiatives it offers, NYU has helped me develop these skills and succeed in my own entrepreneurial endeavors."

— Dan Malamud, Professor of Medicine, NYU College of Dentistry, NYU School of Medicine, Founder, TB Biosciences



All of these companies were founded by NYU students, faculty, or alumni.

Examples of programs and resources include:

I-Corps

The I-Corps program is a seven-week immersive course for faculty and their graduate students/postdocs to help transform academic research into startup ventures. The program uses the Lean Startup methodology to train academic researchers in hypothesis-driven customer discovery. I-Corps was first launched as an initiative by the National Science Foundation and has since been adopted by the NIH and other agencies. Programs are now available for NYU faculty and researchers across all disciplines. Visit: bit.ly/whatisicorps to learn more or contact the NYU Entrepreneurial Institute at entrepreneur@nyu.edu

Startup Bootcamps for NYU Scientists and Engineers

Startup Bootcamps are half-day events intended to expose NYU faculty, graduate students and researchers to the basic activities of commercializing research via a startup venture. Startup Bootcamps are open to faculty and researchers (including PhDs and Post-Docs) across the University. The target audience is individuals or teams from the NYU community who are interested in creating a startup venture based on your research or inventions or simply learning more about entrepreneurship. Visit: bit.ly/nyustartupbootcamps

TAC and ARSF Awards

The Technology Acceleration & Commercialization (TAC) Awards encourage and promote the development of research projects and technologies that have the near-term potential for commercialization through startup creation or licensing. The Awards will support projects from NYU's Washington Square, Dental School, and NYU-Poly campuses. Similarly, the Applied Research Support Fund (ARSF) exists to encourage and promote the development of original research projects and technologies developed in whole or in part at the NYU School of Medicine. Visit: nyu.edu/oil

NYU Innovation Venture Fund

The NYU IVF is a seed-stage venture capital fund created in 2010 to invest in startups founded by NYU students and faculty and/or commercializing technologies and intellectual property development at the University. Its primary objective is to bring more innovations developed in the University to market. Visit: nyu.edu/venturefund

NYU Entrepreneurs Challenge – Technology Venture Competition

The NYU Technology Venture Competition serves as a catalyst for the creation of new and the acceleration of existing early stage businesses based on life science, clean/green or information technologies. Sponsored by the NYU Entrepreneurial Institute, the competition awards a total of $75,000 in cash prizes to the winners. Visit: bit.ly/entrepreneurschallenge

Learn more about the NYU Entrepreneurial Institute:

website: nyu.edu/entrepreneur
email: entrepreneur@nyu.edu
twitter: @nyuentrepreneur

Breakout

sessions

BREAKOUT SESSIONS

GROUP 1: "How do changes in the early stage environment affect the evolution of venture capital models? How can public policies find a balance in the support they provide to early vs. later stage financing?"

Moderator: **Dr. Thomas Hellmann**
Professor of Entrepreneurship and Innovation
Saïd Business School
Oxford University (UK)

GROUP 2: "How do university innovation initiatives fit into the broader early stage financing environment"

Moderator: **Dr. Ajay Agrawal**
Peter Munk Professor of Entrepreneurship
Rotman School of Management
University of Toronto (Canada)

GROUP 3: "Which LP funding models are working? What will it take to get the interest of institutional investors into VC? Can VCs instead get funded from alternative LPS, such as corporates?"

Moderator: **Mr. Neal Hill**
Vice President, Fund of Funds
Business Development Bank of Canada (Canada)

Group 1: Moderator

Dr. Thomas Hellmann
Professor of Entrepreneurship and Innovation
Saïd Business School
Oxford University (UK)

Dr. Thomas Hellmann is a Professor of Entrepreneurship and Innovation at the Saïd School of Business at Oxford University. He holds a BA from the London School of Economics and a PhD from Stanford University. He previously was a member of faculty at the Graduate School of Business, Stanford University, and the Sauder School of Business, University of British Columbia. He also held visiting positions at Harvard Business School, the Wharton School (University of Philadelphia), Hoover Institution (Stanford), INSEAD (France) and the University of New South Wales (Sydney, Australia).

Professor Hellmann has taught executive, MBA and undergraduate courses, mostly in the areas of entrepreneurship and entrepreneurial finance. Professor Hellmann's research interests include entrepreneurial finance, entrepreneurship, innovation, strategic management and public policy. Professor Hellmann has been a consultant to private and government clients. For example, he wrote a report about the role of government in venture capital for the World Economic Forum in Davos. He also led the evaluation report of the venture capital program in British Columbia.

His academic writings have been published in many leading economics, finance and management journals, including The American Economic Review, Journal of Finance and Management Science. Professor Hellmann has written numerous case studies on entrepreneurship and venture financing. He is also the founder of the NBER Entrepreneurship Research Boot Camp, which teaches the frontiers of entrepreneurship economics and entrepreneurial finance to PhD students.

Group 2: Moderator

Dr. Ajay Agrawal
Peter Munk Professor of Entrepreneurship
Rotman School of Management
University of Toronto (Canada)

Ajay Agrawal is the Peter Munk Professor of Entrepreneurship at the University of Toronto's Rotman School of Management, Research Associate at the National Bureau of Economic Research in Cambridge, MA, Co-Founder of The Next 36, and Founder of the Creative Destruction Lab at the University of Toronto.

Professor Agrawal teaches courses on business strategy, innovation, and entrepreneurship. He was recognized as "Professor of the Year" by the past seven consecutive graduating MBA classes. Professor Agrawal conducts research on the economics of innovation and creativity. He has presented this work at a variety of institutions including Harvard, MIT, Stanford, Berkeley, London Business School, Wharton, London School of Economics, Industry Canada and the Federal Reserve Bank.

Professor Agrawal advises firms and governments in fields related to innovation and strategy and has testified as an expert witness.

Group 3: Moderator

Mr. Neal Hill
Vice President, Fund of Funds
Business Development Bank of Canada (Canada)

Neal Hill joined BDC Venture Capital in 2012 as Vice President, Fund Investments. His main responsibilities are to develop BDC Venture Capital's reputation as an institutional investor of choice in venture-focused private equity funds, expand BDC's industry presence and develop sector knowledge, and identify and develop high-potential general partners (GPs).

Mr. Hill has more than 30 years of experience in technology management and marketing, venture capital, and mergers and acquisitions in Canada and the U.S. Before joining BDC, he held senior management and consulting positions in various sectors. Most notably, he was founder and Senior Managing Director of Great Northern Capital, Canada's first attempt to create a growth-stage venture capital fund of substantial size focusing on emerging technology firms. Prior to this, he was Senior Vice President, Corporate Development, for Cognos Incorporated, the Ottawa-based $1 billion worldwide leader in business intelligence and performance management software, now a unit of IBM. In this role, he was responsible for mergers, acquisitions and strategic alliances, including the IBM alliance that led to its acquisition of Cognos. From 1997 to 2004, he was also Managing Director and Director of Investments at VIMAC Ventures of Boston, an early-stage Information Technology venture fund.

Mr. Hill pursued a Bachelor of Arts with a major in Physics and Political Science at Washington University in St. Louis, Missouri.

Breakout session 1

Public Policies for Venture Capital: Early- versus later-stage funding gaps?

In this informal and interactive group discussion, we will examine some of the recent debates about challenges in the venture capital industry, and the role of public policy. Among other things we will examine the implications for venture capital of early stage policies that support early stage investors other than venture capitalists (e.g., angels). We will also address the debate that policy makers should pay more attention to later stage financing, such as the recently issued Global Scale-Up Declaration.

Group's background information:

The Global Scale Up Declaration

Daniel Isenberg & Linda Rottenberg

New York, NY

https://www.change.org/p/the-global-scale-up-declaration-join-the-scaleupdeclaration-conversation

By Daniel Isenberg*, Fadi Ghandour, Gregoire Sentilhes***, Sherry Coutu****, Calestous Juma*****, Linda Rottenberg and Colleagues******

September 4, 2014

In upcoming November's Global Entrepreneurship Week millions of people in 140 countries will participate in over 10,000 events to celebrate entrepreneurial startups. We believe that entrepreneurial scale ups are an essential yet underemphasized part of this crucial global conversation. Entrepreneurial scale ups are companies – young or old – which are run and owned by growth-driven business owners and leaders which at any stage of their lives may launch a new growth trajectory. Scaling up, which by definition reflects new value creation in the world's marketplaces are the guiding North Star in this dialog because, as research has shown in many countries, scaling up companies are the drivers of both economic and social prosperity. Furthermore, we also know that these value creating companies may be startups, family businesses, spinoffs, acquisitions, and buyouts, in any industry, service, or business sector.

To accelerate and highlight the scale up conversation, with a group of entrepreneurship influencers, we have developed this Scale Up Declaration, which we offer as a rallying point for what the entrepreneurship discussion should focus on, and what that can accomplish. We hope the Scale Up Declaration will gain momentum as a major factor in creating an aligned, accurate and comprehensive view of entrepreneurship.

Therefore, we declare that:

- From the dawn of human society, entrepreneurship - the creation of value by scaling an enterprise has always had a positive and unique social and economic impact on those societies;

- Great and successful entrepreneurs have always been, are, and will always be an essential part of great societies as job and wealth creators, innovators and, very often, philanthropists;

- Great entrepreneurs benefit society first by scaling up as far and fast as possible, and then by reinvesting their success as inspiring role models, their knowledge as mentors or teachers, and financial gain, as investors in the next generation of entrepreneurs;

- A scale up mindset – the powerful ambition to continually grow and have an impact on the marketplace – is the most important attitude of successful scale up entrepreneurs;

- Scale up skills – leadership in bringing products and services to new and existing markets, while attracting and growing human, financial and customer capital to pursue it, as well as learning quickly from mistakes – are the most important skills that entrepreneurs can learn;

- The quantity and success of local scale up entrepreneurs increases the quantity and success of other manifestations of entrepreneurship, including startups, small business, and family business;

- Scale up entrepreneurship applies to every sector, whether services, manufacturing, information, media, health care, real estate, or biotechnology.

- We all – educators, foundations, governments, investors, bankers, business people, entrepreneurs and all leaders in civil society – can and should do more to encourage scale up entrepreneurship in our regions and in the world;

- Finally, we pledge to communicate through every available media channel (including email, Twitter, Facebook, and printed) the concepts and principles in this global Scale Up Declaration with the hashtag #ScaleUpDeclaration.

* Professor of Entrepreneurship Practice, Babson; Founder, Scale Up Milwaukee

** Founder and Vice Chairman, Aramex; Executive Chairman, Wamda Capital

*** Co-founder and former Chairman, G20 YES; Founder and CEO, NextStage

**** Entrepreneur and Angel Investor

***** Professor of the Practice of International Development, Havard Kennedy School

****** Founder and CEO, Endeavor, with special thanks to Endeavor President Fernando Fabre

HBR Blog Network

Focus Entrepreneurship Policy on Scale-Up, Not Start-Up

by Daniel Isenberg | 10:00 AM November 30, 2012

Would you allocate more of society's resources to giving birth to more babies or to raising children well? Now, think about enterprise creation and the challenge of economic growth. Societies' leaders need to rebalance entrepreneurship policy towards scale, not start.

In recent years, we have been witnessing a significant global shift in attitudes towards entrepreneurship in countries around the globe. This is reflected in the dramatic proliferation of start-up programs: Start-up America (http://www.s.co/) , Start-up Chile (http://startupchile.org/) , Start-up Russia (http://www.startuprussia.org/) , Start-up Britain (http://www.startupbritain.co/about-us/) , Start-up Weekend (http://startupweekend.org/) , and dozens of others. "Start-up" has replaced "Silicon" as the reigning entrepreneurship buzzword: There is hardly a country or city that is lacking a start-up program.

Unfortunately, this is being guided almost exclusively by a narrow conception of entrepreneurship as consisting primarily in the starting-up of an enterprise. Equating entrepreneurship with start-up is not wrong; it is just very incomplete. It is also problematic because of two flawed implied messages: The first is that the most difficult and important task of the entrepreneur is launching his or her venture. The second is a notion we might call "the more the merrier" — i.e., the more start-ups, the more successful the program. Quantity of start implicitly trumps quality of scale.

Both of these messages are doubtful. If we look at entrepreneurship in terms of extraordinary value creation and capture, which I do, then it is clear that value can be created and captured in a large variety of ways, and there is no *a priori* reason to think doing this from scratch via a start-up is the only or even the best way. Extraordinary value creation may involve acquiring, re-purposing, spinning off, or recombining underutilized or undervalued assets, or what my Stanford colleague George Foster calls "re-starts." The Kaspersky's, for example, founded their leading anti-virus company by spinning it out from a struggling Russian institute they worked for. Over the past decade or so, search funds have become an effective vehicle for acquiring undervalued companies to infuse with capital, management and growth. Family businesses, large corporations, R&D centers and universities — any of these can be essential in creating or freeing up assets rich with untapped potential. And yet:

Extraordinary value creation cannot occur without growth, and entrepreneurial growth post start-up has numerous challenges which can be an order of magnitude more difficult than simply starting a venture. Growth entails developing a powerful sales and marketing machine, building an organization by hiring and managing diverse groups of people, and knowing how to acquire strategic inputs such as the right kinds of capital and suppliers. Growth requires amazing amounts of energy and dedication, not to mention smarts. Forward-looking policy, as well as culture and the private sector, must support all these skills and resources more than it does at present.

Indeed, when I dig into examples of start-up programs, ranging from Scandinavia to the Middle East to both North and South America, scale-up is the far bigger challenge: After two years and $12 million, Start-up Chile's largest

resident start-up employs three people, according to Horacio Melo, the CEO. A comprehensive set of start-up programs and policy reforms in Denmark in the early 2000s led to a dramatic increase in the numbers of ventures formed, but when analyzed five years later, the vast majority had plateaued at a few employees, and fewer than 1% met the fairly modest criteria set to be considered "growth" ventures.

Chile and Denmark's policies are not "wrong" (in fact, in Denmark this finding has provided policy makers additional impetus to strengthen efforts to crack the code of scale). The lesson is: scale-up is so much harder than start-up entrepreneurs (and policy leaders) realize. As one of my successful entrepreneur friends warns, "This is tough bloody s[***]." We need to turn the focus on growth-after-start: growth will not somehow take care of itself. To return to the imperfect analogy of my lede above, anyone who has been a parent knows that the long and complicated job of growing a healthy, educated and moral child is vastly more challenging than giving birth. I vividly remember how our first birthing class spent hours on breathing and epidurals, yet I had no clue about how to change a diaper or deal with a rash let alone be a father of teenagers! And societal resources required to formally and informally prepare parents for and support them in parenthood are immeasurably greater than for the birth process itself.

So it is just now dawning on many in business and government that when these start-up programs are successful in stimulating venture birth rather than venture scale, the tremendous challenges of growth may paradoxically become worse, not better, and can leave many stagnant or overvalued ventures that may have little real prospect of growth.

We can refocus policy on scale-up in a number of ways. One is structural: stop treating venture survival as an indicator of policy success and start looking at those that grow. It is also necessary for policy to facilitate extremely high levels of venture death and recycling in order to avoid a plethora of valueless start-ups. Focus much more attention on enriching the local labor pool, an essential aspect of an effective ecosystem. Entrepreneurs I meet with from Boston to Bangalore to Barcelona who have succeeded in obtaining market traction almost universally complain about the paucity of appropriately skilled people and managers to hire. Entrepreneurial ventures can never grow without talent, and the two basic types of talent needed — new employers and new employees — must evolve together.

Furthermore (and here is where the parenting analogy breaks down), experience and the existing data suggest that a very small number of high-growth ventures may be sufficient to generate almost all of the social and economic benefits of entrepreneurship. One venture which grows to 100 people in five years is probably more beneficial (to entrepreneurs, shareholders, employees, and governments alike) than 50 which stagnate at two. Endeavor (http://www.endeavor.org/blog/category/research/) has recently shown that just two or three unusually scaling ventures can have an utterly disproportionate impact on dozens of successors, and impact the entrepreneurship culture in a region.

Which is more important, giving birth or raising children? Obviously, birth is necessary, but it is greatly insufficient. In focusing entrepreneurship policy almost exclusively on start-ups we are favoring quantity of start-up at the expense of quality of scale-up.

HBR Blog Network

How to Finance the Scale-Up of Your Company

by Daniel Isenberg and Daniel Lawton | 10:00 AM August 18, 2014

Tom Szaky (https://www.google.com/webhp?sourceid=chrome-instant&ion=1&espv=2&ie=UTF-8#q=tom%20szaky) knows well the meaning of the saying **"**Beware your dreams, for they may come true.**"** With the 2004 Christmas retail season rapidly approaching, he was trying everything he could to scale up TerraCycle (http://en.wikipedia.org/wiki/TerraCycle) , a two year old venture selling liquid worm poop as fertilizer in used PET bottles. So far, he had been successful distributing through lots of smaller retailers, but had encountered a flood of rejections from the big box stores. Undaunted, Szaky finally landed a 15 minute meeting with Walmart Canada's buyer. Instead of telling Szaky to "drop off the face of the earth" (he had been warned this was likely) Walmart Canada placed a huge order — for every one of its stores. But as he recounts in his engaging book (http://www.amazon.com/Revolution-Bottle-Terracycle-Eliminating-Waste-ebook/dp/B008MG40Q4/ref=sr_1_1?ie=UTF8&qid=1408028752&sr=8-1&keywords=szaky) , achieving his dream quickly turned into a nightmare when he was confronted with a stark reality: they had sold to Walmart without having the necessary infrastructure in place to handle the huge volume increase. Fortunately for Szaky, he *had* already laid the groundwork of financing from suppliers, equity investors and others to allow them to double sales in two months.

Contrary to conventional wisdom, the most dangerous period for entrepreneurs is not when they start up from scratch but when they scale up for growth. When you are a startup, there is relatively little to lose, mistakes are fixable, and a small amount of cash and a cohort of committed colleagues can go a long way. But when you suddenly accelerate and grow, whatever your company's age, things get really hot really fast, largely because your need for cash explodes overnight. Most entrepreneurial ventures, whether they are startups, spinoffs, or smaller companies which have been around for awhile, haven't given enough thought or planning to financing for rapid scale-up. Here are some ways to keep the heat of new growth from melting you down.

Use multiple sources of finance. Many entrepreneurs who are propelled into a sudden growth trajectory think mostly about raising risk-sharing equity investment from venture capitals or private "angels." But when you scale up, it is faster, more feasible and less dilutive to cobble together your financing from a combination of equity investors, banks, public funds, suppliers, credit cards, customers, and even employees who will take stock options in lieu of some cash. One retailer I know discovered that the $100 or so penalty to defer California sales tax by a month was actually a cheap source of financing. It doesn't make as glamorous a story as "raising $5 million from top-tier Valley VCs," but this is how growth financing typically works in reality.

Cross-leverage money from one source into cash from others. It may seem counterintuitive, but owing money to banks often makes you *more* attractive to equity investors, not less. To the risk investors, bank debt means that very conservative and experienced eyes will be watching your performance so that you make every payment on time. The risk-friendly equity investor also sees the debt as a cheap way to leverage their returns. So when you get some equity investment, rather than looking for more of the same, immediately talk to the bankers, the state funding agencies and other more conservative lending institutions. Particularly with investors and lenders whose interest is in securing the

viability of your growing enterprise, it's to your advantage to ask *before* you secure other sources of financing. This kind of cross-leverage strategy diminishes the inevitable "free rider problem (http://en.wikipedia.org/wiki/Free_rider_problem) " (i.e., we'd love to see you succeed but we're happy to cheer you on from the sidelines).

Speak different dialects with different capital providers. When you do cross over to talk to the bankers or other financers, learn how to speak *their* language. Entrepreneurs often get caught up in the heat of the moment: "My venture is scaling up so fast, what an opportunity!" Banks don't care about opportunities in the abstract — they care about opportunities that repay their principal plus interest, on time, or else securing the debt with other assets they can seize. Public funders — the various state economic development agencies — don't care about opportunities in the abstract, either, but about opportunities that create jobs, particularly where unemployment is raging. Research institutes, for example, care about seeing their IP solve important problems so they can get more funding themselves. Philanthropies and advocacy groups with funds to disburse care about progress in their area of focus. You get the point. In dealing with diverse potential funding sources throughout your enterprise's growth, you always need to keep top-of-mind the question "What's in it for *them*?"

Be opportunistic about raising money. Of course, both business school and real life experience teach us that it helps to plan out your moves in advance — and it does. But scaling up rapidly is more like piloting a sailboat in open waters than running a train along fixed tracks: chart your course, but take advantage of the waves, currents and weather, and nimbly avoid storms when they approach. Vaunted valley VC, Eugene Kleiner (https://www.google.com/webhp?sourceid=chrome-instant&ion=1&espv=2&ie=UTF-8#q=Eugene%20Kleiner) said it well: "The time to eat the hors d'oeuvres is when they're being passed round (http://www.economist.com/node/2265786) ." Many an entrepreneur has passed on the hors d'oeuvres, only to regret it later. As an investor, I have seen quite a few ventures fail from running out of cash. I have yet to see a venture fail from too much dilution.

Manage accounts receivable like a hawk, but pay on time. In my company (Isenberg) we developed a 90-day rolling prediction of our daily account balances that, over the years, became increasingly precise. This saved us hundreds of thousands of dollars in financing. Managing payables is just the flip side of the receivables coin. Pay on time. I know this sounds counterintuitive. Like most firms, my company weathered numerous market ups and downs. Because we meticulously paid suppliers on time when we were cash-rich, we could go back to them for additional time to pay when times were tight. Supplier financing is a powerful, hidden source of cash that works best when times are bad, and is much harder to secure when times are good.

Cultivate customer financing. The flip side of supplier financing is to ask your customers for financing. This can take different forms, including up-front payments, down payments, or covering some of your development expenses, usually of course for a discount on their purchases from you in the future. To secure financing from customers is not necessarily easy: to get it, you will need to understand deeply what their needs are (present or future) and present a compelling pitch for how you can address those needs better than anyone else. In contrast to supplier financing, customer financing is usually more feasible when times are good and customers have cash on hand. But remember, both customer and supplier financing will require you to be skillful in showing how you compellingly address their unmet needs: for example, suppliers want to have a reliable, long term customer who pays predictably; customers want to have the most advanced technology that will give them a competitive edge.

All successfully growing entrepreneurs keep their eye on cash flow and they do it best by having a broad range of capital sources — and cash substitutes — to draw on. Remember, whether you are a later stage startup or a second generation family venture, a thoughtful and flexible financial plan focused on scale-up will allow you to grow fast, be responsive, and thrive.

BY ELISABETH B. REYNOLDS AND HIRAM SAMEL

The United States is synonymous with innovation. Many of the new century's core technologies—from semiconductors and flat panel displays to biomedical devices and photonics—were invented in the States. Yet today, many of these products are manufactured elsewhere. This is especially true when small, entrepreneurial firms develop complex, innovative technologies.

Over the past 30 years, powered by the rise in venture capital, startups have played an increasingly important role in transforming laboratory innovations into marketable products. Yet, after years of refining prototypes and perfecting pilot plants, advanced manufacturing startups frequently look overseas when it comes time to scale up for commercial production.

There are several reasons why. First, there is financing. The United States has an entrepreneurial culture and robust capital markets. After Israel, we lead the world in venture capital as a percentage of gross domestic product. This is a good place to launch innovative ideas.

Yet many investors, particularly venture capitalists, want to exit their investment within about seven years. Software start-ups often fit that time frame. If the venture is successful, investors can achieve quick returns, and occasionally generate enormous profits. They may invest heavily in people, but need little in the way of physical capital.

Manufacturing is different. It usually takes more time and money to develop workable prototypes and the production processes to build them. Then manufacturers must raise even greater sums to reach commercial production. Rather than raise more capital in the face of continuing technological and market risk, many investors prefer to sell the business for a profit.

Second, manufacturing startups often require help scaling up their complex production processes. While some companies seek high volumes and low costs, many others make low-volume products that require highly sophisticated and expensive production systems. This requires skills and know-how learned only by developing new processes at scale. Many countries and regions, particularly in Asia, have expertise in this area.

When startups scale their manufacturing elsewhere, the United States loses more than a possible return on the research investment that made such breakthroughs possible. It also loses the skills and know-how, jobs, and investments that come with engaging with production at scale.

THE UNITED STATES MAY BE ENDANGERING ITS ABILITY TO INNOVATE IN THE FUTURE.

More troubling, because the development of pioneering products and their production processes are so intimately entwined, the United States may be endangering its ability to innovate in the future.

We came to these preliminary conclusions by following the growth trajectories of 150 manufacturing firms based on MIT technology and founded between 1997 and 2008. These firms are arguably among the most likely advanced technology start-ups to succeed. They are at the technology frontier in their fields. By virtue of their connections to MIT and Massachusetts, they are part of one of the world's great innovation "ecosystems" for venture capital and other resources. Of course, these firms are not a representative sample of U.S. manufacturing startups. As a result, our results and conclusions are preliminary

pending further study. Yet the very factors that set these 150 companies apart make them an important test of America's ability to support innovative manufacturing. We believe our preliminary findings offer important insights into why so many American manufacturing startups locate their factories offshore.

THE MIT 150

We drew our sample from 150 manufacturers that licensed MIT technology between 1997 and 2008. Six out of 10 companies are still operating and independent. Another 21 percent were acquired, and 20 percent closed. Their survival rate is 150 percent greater than that found in a national study of venture-backed startups. Sixty percent were in the life sciences (biopharmaceutical and medical devices), 17 percent made semiconductor and electronics products, and another 10 percent were in advanced materials.

Although most had no revenue, three had sales greater than $100 million and one greater than $1 billion. We interviewed top executives from 17 of the most successful firms—those with more than $5 million in revenue or more than $50 million in venture capital investment—to learn about their thinking and processes as they moved from R&D to production.

Financing was a key factor for all of these companies. More than half our sample (82 companies) received venture capital, and raised a total of $4.7 billion. On average they raised $74 million, with 33 firms raising over $50 million each, and 14 more than $100 million.

They continued to raise funds for many years. After seven years, close to 40 percent of the firms were still raising funds. In fact, the average age of firms receiving venture capital was nine years. Only nine firms (eight biomedical companies and a battery maker,) raised funds through an initial public offering, which speaks to both the unique conditions that exist for biomedical companies and the decline in IPOs generally in the United States.

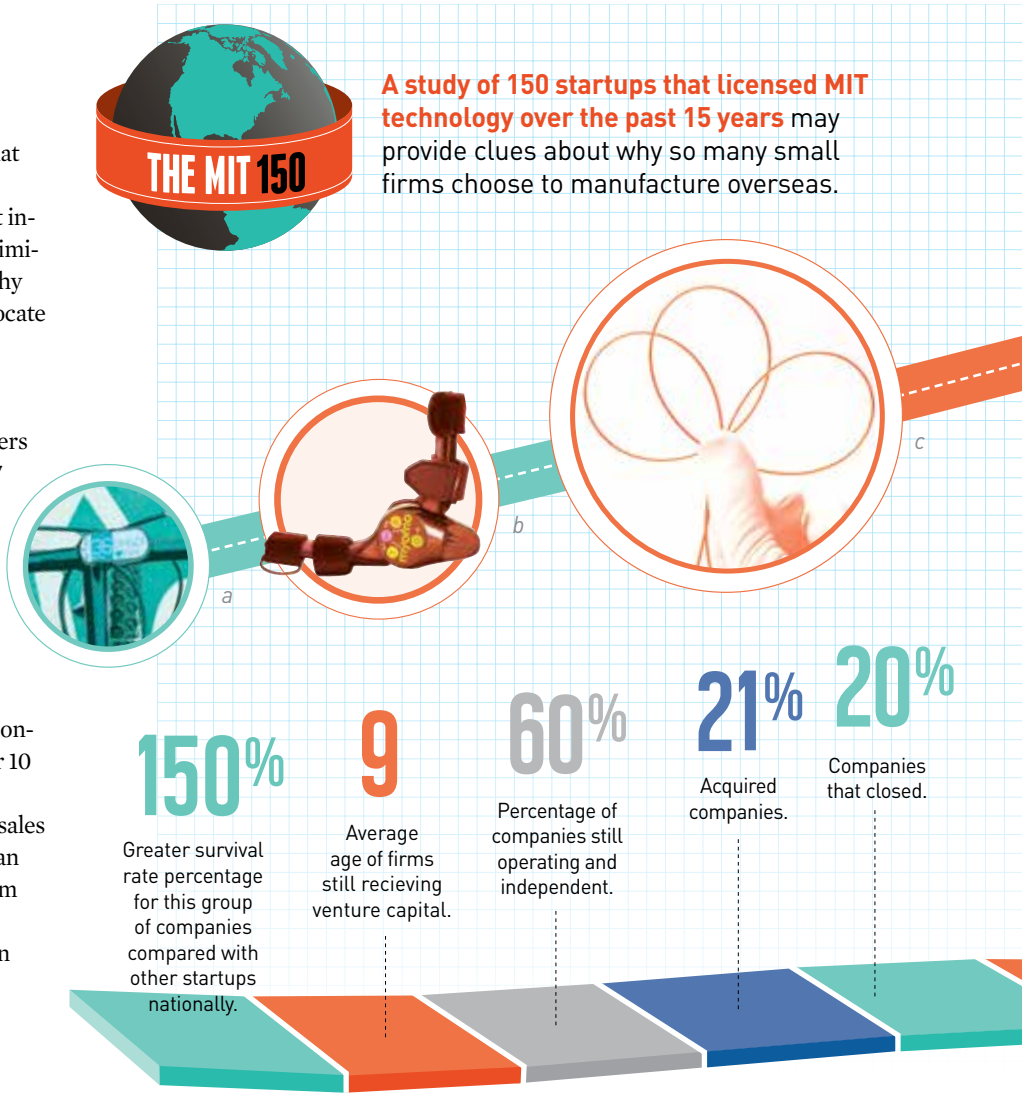
Most of the MIT 150 located in or near established innovation ecosystems, such as Boston, Silicon Valley, and Austin. These ecosystems provide specialized academic laboratories, skilled workers (particularly engineers), and business and technical capabilities, as well as experienced suppliers.

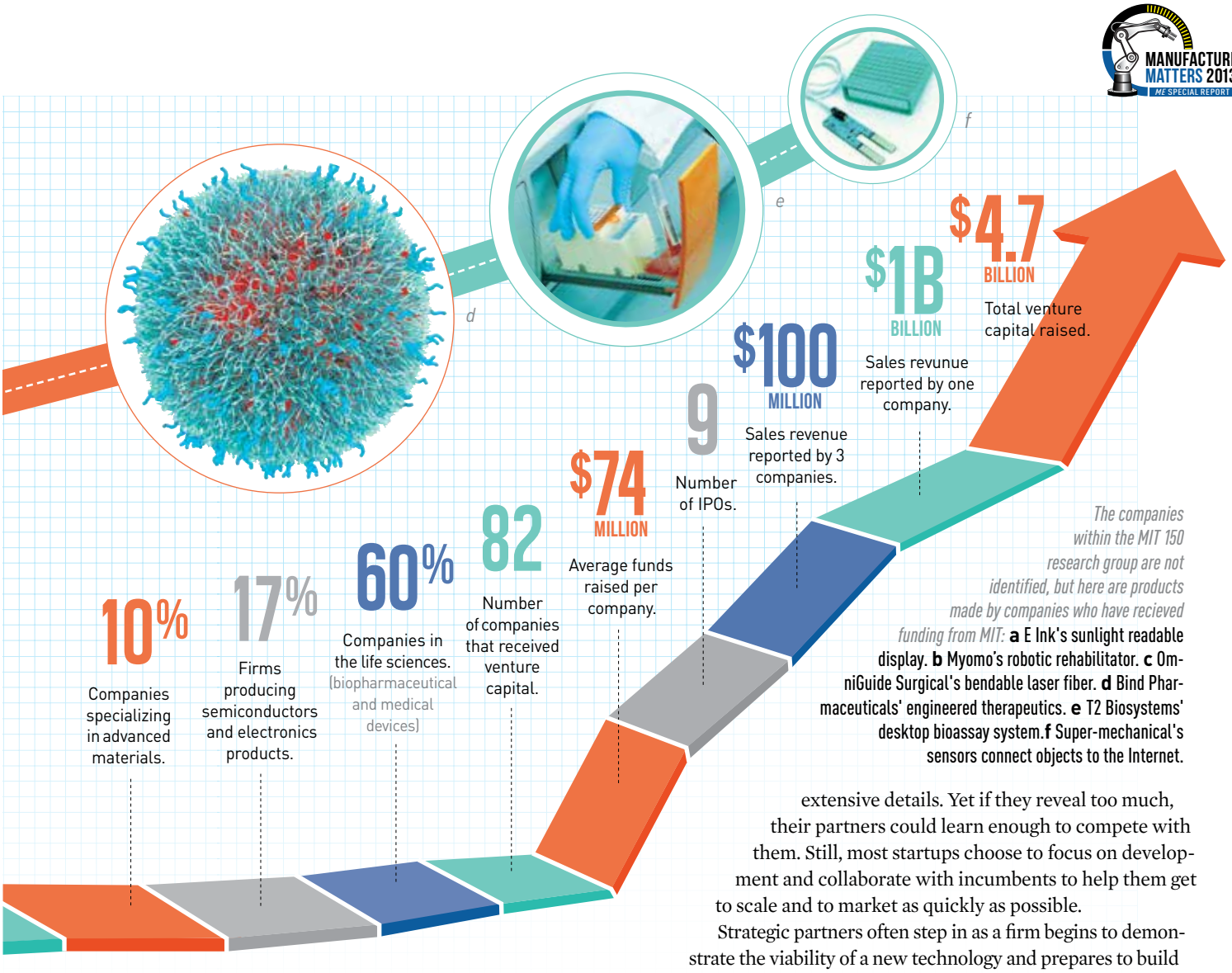
Another critical factor for growth was access to specialized skills, often across several disciplines. We interviewed one firm that hired 25 equipment, process, and device engineers plus an entire microelectromechanical systems team virtually overnight. Industry veterans are also important because they can help a new company understand how their technology might be utilized by existing industry players.

A strong network of suppliers, whether immediately near the company or a short flight away, can help with the early prototyping and pilot production. Because startups develop products and production processes iteratively, they are almost always more concerned about speed and quality than cost. Locating near suppliers lets them turn lessons learned into new prototypes and pilot lines faster.

Time is of the essence. One West Coast firm built a semiconductor equipment prototype in four months and released a new version every six months for three years before it was ready to ship. An East Coast semiconductor firm built its own plant because it lost too much time and control working with a third-party fabricator. (Moving offshore during early develop-ment was never an option because the firm would have lost 18 months transferring its technology.)

Overall, the U.S. provided fertile ground and several strong ecosystems for these companies to get their ideas into early stage production and demonstrate their viability at a pre-commercial stage.





The companies within the MIT 150 research group are not identified, but here are products made by companies who have recieved funding from MIT: **a** E Ink's sunlight readable display. **b** Myomo's robotic rehabilitator. **c** OmniGuide Surgical's bendable laser fiber. **d** Bind Pharmaceuticals' engineered therapeutics. **e** T2 Biosystems' desktop bioassay system. **f** Super-mechanical's sensors connect objects to the Internet.

LEARNING BY BUILDING

Most startups face significant financial constraints as they try to scale. Limited funds must be used wisely to build a team, develop a new technology, and prove its viability before money runs out. Particularly for firms engaged in advanced manufacturing, the costs and know-how needed to build new facilities can be prohibitive.

Rather than funding every capability and resource needed to scale internally, many startups seek complementary assets from established firms. These might include specialized capabilities in production, distribution, or marketing. By partnering with a larger, more established firm, the startup saves money and can get its product to market faster.

Of course, young firms must walk a fine line when they do this. The most relevant complementary assets are usually owned by firms that have similar technologies or already serve a startup's target market. Those established businesses are potential competitors and have incentives to expropriate the inventors' technology.

This presents a challenge. To maximize the value of their technology to potential partners, entrepreneurs must disclose extensive details. Yet if they reveal too much, their partners could learn enough to compete with them. Still, most startups choose to focus on development and collaborate with incumbents to help them get to scale and to market as quickly as possible.

Strategic partners often step in as a firm begins to demonstrate the viability of a new technology and prepares to build it at a commercial scale. This process can take several years and cost millions of dollars (hundreds of millions in the case of energy). For these reasons, we call this an "inflection band" in the development of the company (rather than an inflection point). It is critical in the firm's growth. A large influx of capital is required as the company engages in learning by building as it develops the new product and process for a commercial market.

This iterative type of learning generates significant new capabilities and often occurs across company boundaries. It requires proximity and face-to-face interactions with team members, partners, early customers, and vendors. The tacit knowledge generated at this stage of development is very complex, often unwieldy, and not easily reduced to simple instruction. This makes it sticky, generally restricted to those who work with it most and hard to communicate over distances.

In the past, this stickiness often kept developing technologies from moving offshore. The tacit knowledge they created and shared took root in their local innovation ecosystem. This is still largely the case for the early prototyping and pilot production of new technologies. Yet improvements in communication technology and the increase in capabilities and resources abroad have made it easier to separate core research and development while moving the production processes, still in the development stage, somewhere else.

PULLED OVERSEAS

A majority of the companies we interviewed found the scaleup capital they needed from corporate investors. These included multinational companies interested in the technology and foreign governments interested in learning about specific technologies in order to build similar capabilities in their countries. Government capital, for example, has helped establish Singapore in biotechnology, Russia in nanotechnology, and China in clean energy.

These investors often can take a longer-term view and do not require the same returns sought by venture capitalists. This makes them an attractive financing option for growing firms. In addition, these partners may provide land, training, facilities, know-how, and other important resources.

Moreover, additional venture capital is less readily available at this point. As the CEO of an advanced materials company said, "Venture capitalists cannot make money on something that costs $100 million and takes at least 10 years to build. The technological risk is high and there is a high burn rate. They are much more comfortable with a software deal that will cost them $20 million. They have to pull away just [when the company] is trying to finalize the product and get it ready for commercial production." His firm ultimately raised $40 million from a government investment fund in an emerging economy when he promised to locate some R&D and manufacturing there.

After canceling plans for an IPO, another advanced materials company agreed to a $30 million investment from an Asian multinational. According to the materials company's CEO, his investors were "willing to trade upside for certainty. The investors understood the possibility of acquisition by a foreign firm when they took the money in the last round."

A surgical device manufacturer proved the exception to the rule. It had burned through $125 million in venture capital, yet management fought investors who wanted to sell. Instead, the firm raised funds through an IPO. As a senior executive at the company noted, "98 percent of the conversations in Silicon Valley are around an M&A exit, not an IPO."

As a result of the relationship with these new investors, scaleup during the inflection band often occurs in the new partner's country or production center. Startups are pulled overseas by the complementary assets provided by these new partners, or possibly by suppliers, or lead customers.

This is not surprising. The center of gravity in many industries has shifted overseas. Some of the largest companies have located the expertise needed to scale new technologies in production operations abroad. In these cases, the new capabilities created through learning by building take place in local innovation ecosystems outside the United States.

Our interviews showed how this pull works. For example, one biomedical device company needed injection mold precision plastic and rubber components in high volumes. Attempts to partner with U.S. firms resulted in very low yields. Larger U.S. businesses turned away because the technology was so different from their conventional processes.

Singapore attracted the company with $30 million in government investment, a promise to develop manufacturing capabilities based on its semiconductor experience, and intellectual property protection. The firm was one of the first to move production to Singapore, and has since gone public.

Several startups moved to Asia to be near customers. One CEO counted only 10 potential customers for his semiconductor equipment. The five most important

"BOTH MANUFACTURING AND TECHNOLOGY COMPANIES GO ABROAD LOOKING FOR PARTNERSHIPS BECAUSE IT IS EASIER FOR INVESTORS."

are in Asia. His firm chose to work with a lead customer that would respect its IP.

The CEO and several engineers plan to move next to the customer's plant when their demonstration run begins. The pilot will cost $30 million and a full commercial production facility will cost $150 million. They expect to engage the customer for the investment going forward.

A third company manufactures devices based on specialized electronic inks that it developed with several strategic partners. The CEO said he has little choice but to build his 50-billion-unit manufacturing plant in Asia. He believes many young firms make the same choice because of the complexity of their technology and the capital needed to develop it.

"When they transition from the normal VC model, there is no other model to jump to, so they go abroad," he explained.

Often, they wind up being acquired. "The partner thinks, 'We're going to manufacture this stuff, so why not acquire the company instead of being a partner?' " he said. "Both manufacturing and technology companies go abroad looking for partnerships because it is easier for investors."

INNOVATION IN THE LONG RUN

Each of the firms we interviewed based the decision to develop technology abroad on what was best for the company and the investors. Yet taken together, their decisions represent a loss for the United States in terms of the knowledge, skills, and capabilities that come with commercialization.

The United States remains preeminent in basic research. Its universities and national laboratories rank among the world's most productive. U.S. startups excel at transforming their scientific insight into new products and manufacturing processes that increasingly drive global innovation. America's vibrant venture capital markets and U.S. innovation ecosystems provide the financing and complementary assets to build unique prototypes and pilot lines.

Yet the system falters when innovative companies need significant injections of capital as well as the capabilities to scale to commercial production. When these firms head overseas, they often take their tacit knowledge—the knowledge that has taken years to develop—with them.

In this increasingly interconnected world, there is no a priori reason any company has to stay home to grow. It makes sense to move where the talent, financing, and capabilities are. Nevertheless, we should understand what is gained and what is lost in this process for the country as a whole.

Why does this matter? First, it deprives the United States of new learning. The country loses the knowledge, skills, and capabilities that come with this next stage of scaling, and this diminishes its ability to innovate—much less build to scale—in the future.

Second, it shifts the center of gravity for many industries further away from the United States. Those centers attract the top talent and most innovative technologies. This has implications for future growth.

Third, and most fundamentally, it limits the economic benefits—investments, research, jobs, and new businesses—that arise from manufacturing industries. It may require private and public intervention to preserve those capabilities in the United States.

The U.S. already invests in the early growth of innovative companies. Its methods range from R&D tax incentives, favorable licensing laws, seed capital, and shared research facilities to Small Business Innovation Research grants and university-funded research and incubators.

This problem requires further research and analysis at a much larger scale. But we would like to raise four possible areas that might help to make the United States a more compelling location for scaling innovative production-oriented companies:

WHEN FIRMS HEAD OVERSEAS TO SCALE THEIR PRODUCTS...

THE U.S. LOSES THE KNOWLEDGE, SKILLS, AND CAPABILITIES THAT COME WITH THIS NEXT STAGE, AND THIS DIMINISHES ITS ABILITY TO INNOVATE IN THE FUTURE.

1. Increase financing options for later stage development.
2. Create institutions and incentives that build capabilities for scaleup in this country.
3. Change the contours of market demand through federal and state procurement or standard setting.
4. Encourage firms to raise capital through IPOs, thus making them less reliant on outside funding.

Just as our research is preliminary, these suggestions are meant to begin a conversation that looks beyond U.S. excellence in innovation and company formation. To fully realize the economic gains associated with innovation, new products and services developed by American innovators must be scaled up within the U.S. economy, as well as in overseas markets.

Many of these innovative firms have benefited from U.S. R&D programs. Is it not reasonable to ask whether the country should care how those investments pay off in the long run? ME

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Post-Investment Migration of Canadian Venture Capital-Backed New Technology-Based Firms

Cécile Carpentier, Jean Marc Suret

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Post-Investment Migration of Canadian Venture Capital-Backed New Technology-Based Firms*

Cécile Carpentier†, *Jean Marc Suret*‡

Résumé/abstract

Numerous innovative Canadian new technology-based firms migrate abroad when local venture capitalists exit. This article aims to determine how common this type of exit is, and to understand the motivations behind and the consequences of these migrations. We use a mixed-methodology approach, combining quantitative and qualitative evidence. At the market level, we find that nearly half of successful venture capital exits from Canadian firms result in migration. Using a pattern matching approach with 14 cases, we show that these migrations are motivated mainly by strategic considerations in the context of a small country with few strategic partners and a small market for innovative products. Acquired firms become truncated companies with declining activities. Only a small proportion of bought-out entrepreneurs reinvest in the local economy. This phenomenon probably has strong negative effects on the creation of new large technological firms and clusters.

Mots clés/Keywords : Migration, venture capital, exit, trade sale.

Codes JEL : L26, M13, G24, G28

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nature biotechnology

PERSPECTIVE

Commercializing biomedical research through securitization techniques

Jose-Maria Fernandez[1], Roger M Stein[1,2] & Andrew W Lo[1,3,4]

Biomedical innovation has become riskier, more expensive and more difficult to finance with traditional sources such as private and public equity. Here we propose a financial structure in which a large number of biomedical programs at various stages of development are funded by a single entity to substantially reduce the portfolio's risk. The portfolio entity can finance its activities by issuing debt, a critical advantage because a much larger pool of capital is available for investment in debt versus equity. By employing financial engineering techniques such as securitization, it can raise even greater amounts of more-patient capital. In a simulation using historical data for new molecular entities in oncology from 1990 to 2011, we find that megafunds of $5–15 billion may yield average investment returns of 8.9–11.4% for equity holders and 5–8% for 'research-backed obligation' holders, which are lower than typical venture-capital hurdle rates but attractive to pension funds, insurance companies and other large institutional investors.

Consensus is growing that the bench-to-bedside process of translating biomedical research into effective therapeutics is broken. A confluence of factors is responsible for such pessimism but one of the most widespread is the sense that the current business model for life sciences R&D is flawed[1–3]. The productivity of big pharmaceutical companies—as measured by the number of new molecular entity and biologic license applications per dollar of R&D investment—has declined in recent years[4], and their stock-price performance over the past decade—an annualized return of −1.2% for the New York Stock Exchange Arca Pharmaceutical Index during the period from 2 January 2002 to 4 January 2012—has been equally disappointing. Despite the near doubling of the aggregate R&D budget of the pharmaceutical industry from $68 billion in 2002 to $127 billion in 2010, there has been little appreciable impact on the number of new drugs approved[5]. Life sciences venture-capital investments have not fared much better, with an average internal rate of return of −1% over the 10-year period from 2001 through 2010 according to VentureXpert data (**Supplementary Empirical Results**).

However, these dismal returns contrast sharply with the many promising breakthroughs that have occurred in biomedicine in recent years, including gene therapies for previously incurable rare diseases, molecularly targeted oncology drugs, new modes of medical imaging and radiosurgery, biomarkers for drug response or for such diseases as prostate cancer and heart disease, and the use of human genome sequencing to find treatments for diseases that have confounded conventional medicine, not to mention advances in bioinformatics and computing power that have enabled many of these applications. Moreover, there are many life-threatening diseases for which the number of afflicted individuals continues to increase—if for no other reason than population growth—implying a growing demand for therapeutics from a grateful and price-insensitive clientele. Why, then, does the industry appear to be so challenged?

Here we propose one explanation for this apparent inconsistency and a possible solution. Our proposed explanation is the trend of increasing risk and complexity in the biopharma industry. This trend can be attributed to at least two distinct sources: scientific advances and economic circumstances. That biomedicine is far more advanced today than even a decade ago is indisputable, but breakthroughs such as molecular biomarkers for certain diseases generate many new potential therapies to be investigated, each of which requires years of translational research at a cost of hundreds of millions of dollars and has a substantial likelihood of failure. Although such complexity offers new hope to the afflicted, it also presents an enormous number of uncertain prospects that must be triaged by researchers, biopharma business executives, investors, policymakers and regulators.

A host of economic and public-policy conditions has also contributed to this uncertainty, including declining real prescription-drug spending; rising drug-development costs and shrinking R&D budgets; the 'patent cliff' of 2012 during which several blockbuster patents will expire; increased public-policy and regulatory uncertainty after the Vioxx (rofecoxib) debacle; the potential economic consequences of healthcare reform; less funding, risk tolerance and patience among venture capitalists; narrow and unpredictable windows of opportunity for conducting successful initial public-equity offerings; unprecedented stock market volatility; and the heightened level of financial uncertainty from ongoing repercussions of the recent financial crisis. Consequently, the lengthy process of biomedical innovation is becoming increasingly complex, expensive, uncertain and fraught with conflicting profit-driven and nonpecuniary motivations and public-policy implications. Although other industries may share some of these characteristics, it is difficult to find another so heavily burdened by all of them.

This trend of increasing complexity and risk implies that the traditional financing vehicles of private and public equity are becoming less effective for funding biopharma because the needs and expectations of limited partners and shareholders are becoming less aligned with

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the new realities of biomedical innovation. The traditional quarterly earnings cycle, real-time pricing and dispersed ownership of public equities imply constant scrutiny of corporate performance from many different types of shareholders, all pushing senior management toward projects and strategies with clearer and more immediate payoffs, and away from more speculative but potentially transformative science and translational research. Private equity may afford more latitude for risk taking and deferred exits, but the scale of capital commitment is considerably smaller and funding decisions are often driven less by scientific breakthroughs than by business cycles and windows for conducting initial public-equity offerings[3,6,7]. Recent financial research suggests that even the mere concern about the availability of future rounds of financing—due solely to the possibility of unfavorable economic conditions—is often reason enough for venture capitalists to shun proven and economically viable technologies[8,9]. Industry professionals cite the existence of a 'valley of death'—a funding gap between basic biomedical research and clinical development. For example, in 2010, only $6–7 billion was spent on translational efforts, whereas $48 billion was spent on basic research and $127 billion was spent on clinical development that same year[5,10].

We propose an alternative for funding biomedical innovation that addresses these issues through the use of 'financial engineering'[11,12], mathematical and statistical models for structuring and pricing various financial securities to achieve specific objectives. Our approach involves two components: (i) creating large diversified portfolios—'megafunds' on the order of $5–30 billion—of biomedical projects at all stages of development; and (ii) structuring the financing for these portfolios as combinations of equity and securitized debt so as to access much larger sources of investment capital. These two components are inextricably intertwined: diversification within a single entity reduces risk to such an extent that the entity can raise assets by issuing both debt and equity, and the much larger capacity of debt markets makes this diversification possible for multi-billion-dollar portfolios of many expensive and highly risky projects. One indication of this larger capacity is the $1 trillion of straight corporate debt issued in 2011 versus the $41 billion of all initial public-equity offerings (excluding closed-end funds) that same year[13].

The need for such large amounts of funding follows directly from the combination of the large out-of-pocket costs required to determine the therapeutic potential of a single compound from its preclinical stages to either approval or withdrawal, and the number of such projects required to achieve a reasonably attractive risk-reward profile for typical investors. The key feature of portfolio diversification is the reduction in uncertainty achieved by undertaking many programs simultaneously. Even though it may be impossible to predict which of these programs will succeed or fail, the likelihood of success increases with the number of programs undertaken.

This obvious statistical fact has some less-obvious financial implications. With enough programs in a portfolio, the potential revenues become more certain, more easily valued by potential investors and more attractive from a risk-reward perspective. As a result, these programs are more readily packaged for a much larger population of investors through financial-engineering techniques such as securitization[14], a financing method in which a pool of investment capital is raised by issuing equity as well as several classes of bonds that differ from each other in their risk-reward profile to a diverse population of investors, and in which the funds are used to invest in various assets that serve as the collateral for the bonds. Moreover, these assets may be diverse, spanning the full range of preclinical research to new drug applications and including royalty interests and licensing agreements as well as private and public equity.

Also, debt financing can be structured to be more 'patient' than private or public equity by specifying longer maturities; 10- to 20-year maturities are not atypical for corporate bonds. Indeed, in May 2011, the Massachusetts Institute of Technology issued $750 million in 100-year bonds at the historically low rate of 5.623%. Such long horizons contrast sharply with the considerably shorter horizons of venture capitalists and with the even shorter quarterly earnings cycle and intra-daily price fluctuations faced by public companies. Through financial engineering, bonds with different maturities can be issued by the same megafund to accommodate the different investment horizons of various types of investors. Therefore, a megafund can tailor the investment horizon of its funding to suit the programs in its portfolio, enabling research to follow the most scientifically productive paths instead of being constrained by financially driven business deadlines.

These benefits are especially relevant for biopharma R&D, for which untimely interruptions due to financial constraints almost always destroy considerable economic value, even for genuinely effective therapeutics. Even the possibility of such interruptions may be enough to alter important strategic decisions regarding research direction in the early stages of drug discovery. The megafund structure mitigates these scientifically perverse (but economically rational) effects, and debt financing still provides useful financial discipline and motivation for the borrower because of the need to make periodic interest payments. However, the ability to defer much larger principal payments is ideally suited to projects with longer-term payoffs such as those in biomedicine.

The megafund in context

Our proposal differs from existing business structures and practices in several important ways, and is not equivalent to creating a large venture-capital fund, a new pharmaceutical company or a biopharma mutual fund.

First, neither the biopharma industry nor their venture-capital investors currently use securitization to finance preclinical or early-stage drug development. Of course, the industry has long recognized the benefits of diversification, as demonstrated by the increasing number of biopharma mergers, acquisitions, consolidations and licensing deals over the past decade. Moreover, debt financing has also been embraced. For example, the $46.8-billion acquisition of Genentech (S. San Francisco, CA, USA) by Roche Holdings (Basel) in March 2009 was partly financed by Roche's $16.5-billion bond issue a month before; this was the second-largest corporate-bond offering of all time. However, both Roche and Genentech are well-established companies with clear and easily valued revenue streams. In the current climate of uncertainty, biopharma companies seem more focused on reducing risk and increasing operating efficiency—by engaging in mergers, acquisitions, licensing deals and joint ventures to produce more reliable revenue streams—than on investing in early-stage projects that are even riskier than their existing business lines.

Second, our proposal is to create a single financial entity that invests in multiple biomedical projects at various stages of their development cycle financed by securitized debt and equity, not to create another large publicly traded pharmaceutical company. Although big pharma companies are central to the later stages of drug development and the marketing and distribution of approved drugs, they do not currently play as active a role at the riskier preclinical and early stages of development for the reasons described above. Megafunds can fill this gap by funding more speculative early-stage R&D in exchange for a percentage of future royalties or proceeds from any subsequent sale of the intellectual property. Such speculative investments require a

much broader set of assets to achieve sufficient risk reduction, which is precisely what a megafund is designed to do.

Also, at earlier stages of development, the required resources per project are smaller and the ability to change direction by discontinuing less promising projects and redeploying capital to more productive assets is considerably easier. Compared with the plethora of small pharmaceutical companies currently pursuing just one or two projects, these savings are especially important for a megafund. It is considerably harder to cull compounds efficiently in a small company because the livelihoods of the employees and management depend on the continued development of the company's few compounds—in these cases, development tends to continue until the money runs out. With a megafund, this conflict is greatly reduced—capital can be more efficiently allocated to projects that are likely to succeed, and failing projects and compounds can be abandoned rapidly. In fact, for megafunds that have invested in a sufficient number of early-stage projects, it may be worthwhile to build and operate shared facilities for conducting preclinical studies motivated by the megafund's projects. Such a 'preclinical incubator' could provide the megafund with valuable economies of scale as well as reduce duplicative costs in the industry.

Third, our proposed megafund is not a biopharma mutual fund, which is simply a pooled vehicle for equity investors and therefore restricted to investing in companies that are already publicly traded. A megafund may invest in such companies, but it can also invest in startups, existing private companies, royalty streams, intellectual property and other assets. Moreover, a megafund will issue both debt and equity, making its capital structure materially different from that of a mutual fund; the business pressures, priorities and horizons it faces are correspondingly different. A megafund's portfolio manager is likely to be much more actively engaged in the scientific and engineering aspects of the portfolio assets, not unlike a traditional venture capitalist; in contrast, a biopharma mutual fund manager is essentially a stock picker whose only involvement in the management of the portfolio companies is through proxy voting decisions.

Despite these differences, a megafund does bear some resemblance to an existing class of business entities in the biopharma industry—drug-royalty investment companies—and this similarity supports the basic premise of our portfolio approach to financing biomedical innovation. Companies like Royalty Pharma (New York), Cowen Healthcare (Stamford, CT, USA) and DRI Capital (Toronto) are investment vehicles that acquire ownership interests in the royalty streams of approved drugs, rather than the equity of biopharma companies. By combining these ownership interests into a single portfolio, these vehicles are able to provide more attractive risk-reward profiles for their investors and can issue debt to finance their acquisitions. For example, the largest of the drug-royalty investment companies is Royalty Pharma, which owns interests in over 30 approved and marketed products—including such blockbusters as Humira (adalimumab), Remicade (infliximab), Atripla/Truvada (emtricitabine, tenofovir), Januvia (sitagliptin) and Rituxan (rituximab)—and interests in five products in late-stage clinical trials and/or under review at the US Food and Drug Administration (FDA). It has assets of over $8 billion as of May 2012, of which $4.1 billion is securitized debt with the acquired royalty streams of approved drugs serving as collateral. Its most recent debt issue occurred on 24 May 2012, a successful offering of $600 million maturing on 9 November 2018, and priced at 98.5 with a borrowing spread of the London Interbank Offered Rate (LIBOR) plus 3.00%—excellent terms considering current market conditions. All three rating agencies have rated this new issue "investment grade," an important designation that makes this debt eligible for purchase under the investment policies of many institutional investors such as pension funds, endowments and foundations. From 2004 to 2011, Royalty Pharma made $5.8 billion in life sciences investments, a notable amount in comparison to the entire life-sciences venture capital industry's investment of $26.3 billion during the same period.

The key difference between Royalty Pharma and our proposed megafund is the investment mandate. Royalty Pharma invests only in revenue-producing intellectual property (that is, royalty interests in FDA-approved products and in product candidates in late-stage clinical development (phase 3), not in preclinical or early-stage projects). As the investment focus shifts to earlier parts of the drug-approval process, the uncertainty becomes greater, calling for larger portfolios and more sophisticated financing and risk-management techniques to generate the same level of diversification and risk reduction. This inverted financing pyramid in which the biggest portfolios correspond to the earliest stages of translational medicine underscores the value of the megafund vehicle.

The feasibility of a megafund

Our proposal is clearly motivated by financial innovations that played a role in the recent financial crisis; hence, it is natural to question the wisdom of this approach. A full accounting of the causes of the financial crisis has yet to be written, and many mutually contradictory narratives have emerged and are still being developed[15]. Nevertheless, several unambiguous lessons can be learned from the crisis that are relevant to our current context. Although there is no consensus yet as to the ultimate causes of the crisis, there is little doubt that securitization was, and continues to be, an effective means of raising capital. Indeed, it may have been too effective[15,16], allowing potential homeowners to tap directly into a much larger pool of capital instead of obtaining mortgages from traditional banking institutions. But several other factors also contributed to the unprecedented amount of mortgage-related debt issued and the subsequent housing boom and bust[17]: a low-yield environment that motivated investors to take on additional risk to capture higher returns; the positive trend in US residential real-estate values over the four decades before the peak of the housing market in 2006 and the widely held belief that it would persist; competition among commercial banks, investment banks and other financial institutions to diversify their revenue streams by entering new businesses such as mortgage lending and structured financing; financial incentives for all parties involved in the securitization process; regulatory forbearance and accounting practices that obscured financial losses and did not adequately prepare for financial-market dislocation; and politicians who advanced the 'ownership society' initiative through legislation and government agencies, such as the Federal National Mortgage Association (Fannie Mae) and the Federal Home Loan Mortgage Corporation (Freddie Mac).

These factors offer important practical insights into the feasibility of creating biomedical megafunds. For example, one insight is the important role that government guarantees played in supporting the housing market: it is much less costly to provide a guarantee that protects bondholders than to purchase the bonds outright[16]. Therefore, the impact of public funds, such as those allocated to the National Center for Advancing Translational Sciences, can be greatly multiplied by using them to provide guarantees of debt-financed private entities engaged in translational medicine rather than investing in those entities directly (**Supplementary Methods: Credit Enhancement**).

Even so, the analogy between megafunds and the mortgage companies of the financial crisis also points to some potential pitfalls to be avoided. Statistical models of the biomedical portfolio returns should

be based on a detailed understanding of the science and engineering underlying the individual projects in addition to an analysis of historical returns. Portfolio valuations should reflect current market realities at all times rather than hypothetical expectations; otherwise, sharp declines and panic selling may be easily triggered when the market's valuation differs greatly from the portfolio manager's. And regulations surrounding the sale of megafund securities—including proper risk disclosure by issuers, suitability requirements for investors and realistic credit analysis—should be strictly enforced. Securitization is a powerful tool for raising capital, but like most powerful technologies, it can be abused when proper controls are not imposed.

From a broader perspective, the recent financial crisis is by no means unique[18], and bubbles and crashes may be an unavoidable consequence of human behavior coupled with free enterprise. Innovation may inevitably lead to irrational exuberance and unsustainable overinvestment, as with Dutch tulip bulbs in the 1630s, biotech stocks in the 1980s, internet stocks in the 1990s and US residential real estate in the early 2000s. Perhaps the most effective remedy may be to recognize the potential for speculation to emerge in any industry and to ensure that those investors who are ill-suited to such boom-or-bust cycles do not become victims of their destructive forces. More positively, if speculative behavior is a fact of economic life, it may be worthwhile to redirect some of this energy toward social priorities, such as reducing the burden of disease.

Nevertheless, throwing money blindly into an underperforming industry is hardly a recipe for success, as several industry experts have acknowledged[3,19,20]. Apart from the concerns related to the financial crisis, there are substantial organizational challenges to deploying large amounts of capital in the biopharma industry, even if megafund financing is feasible. For example, operational complexities of managing a portfolio of highly heterogeneous biomedical projects also increase with scale, which can reduce some of the benefits of diversification. Many venture capitalists have learned the hard way that small is beautiful, and that beyond a certain level of assets under management, their investment opportunity set begins to suffer from adverse selection, attracting more mediocre opportunities and fewer genuine breakthrough companies. A recent study found that the internal rates of return of venture capital funds peaked somewhere between $100 and $250 million and declined when assets exceeded $500 million[21]. This finding may seem to cast doubt on the wisdom of megafunds. However, as discussed below, megafunds are designed to appeal to a different set of investors. Therefore, the return objectives for megafunds do not have to reach the lofty level of historical venture-capital returns because the risk of these investments is commensurately lower. Nevertheless, potential dis-economies of scale must be carefully weighed in determining the optimal size of a megafund, which is likely to differ from one application to the next and should be determined by balancing organizational complexity against scientific, operational and financial synergies.

New business models as well as novel approaches to management, corporate governance and scientific collaboration may also be necessary before larger amounts of capital can be profitably deployed in this industry. Although these important issues lie beyond the scope of this paper, in the Discussion below we provide a brief review of several of the major business challenges to megafund financing as well as some possible solutions. As outsiders to the biopharma industry, we note that many of these implementation issues are beyond our expertise, but based on discussions with a broad cross-section of industry experts, we believe that megafund financing merits further consideration. The analysis in the sections to follow suggests that if these implementation issues can be addressed, the financing techniques proposed here can greatly expand the current scale of biomedical innovation.

For those who are unfamiliar with financial portfolio theory, we present a highly simplified mathematical model in the next section that provides intuition for our approach in an unrealistic but accessible context. We then describe the mechanics of financial securitization—the creation of new securities that are claims on a portfolio of real assets such as biomedical research—after which we present the main results of our paper: a more realistic multiperiod simulation of the financial performance of a cancer megafund based on historical oncology drug-development databases with over 700 compounds in various stages of preclinical and clinical development from 1990 to 2011. We conclude with a discussion of the potential impact of megafunds on various biopharma stakeholders, some practical challenges of implementation and possible solutions.

Portfolio theory

Consider a hypothetical drug-development program requiring $200 million in out-of-pocket costs over a 10-year period during which no revenues are generated, and with only a 5% probability of success (thus, the total cost of developing a single successful drug is considerably higher). Few investors outside the biopharma sector would be tempted by such an opportunity, even though the expected rate of return on this investment may be quite attractive. In fact, if such a drug were a blockbuster (which is consistent with the assumed 5% success rate), it is plausible to assume that it could generate a net income of $2 billion per year over a 10-year period of exclusivity from years 11–20. The present value of this income stream in year 10 is $12.3 billion (using a 10% cost of capital[22]), implying an expected compound annual rate of return of 11.9% = $(0.05 \times \$12.3/\$0.2)^{1/10} - 1$ over the 10-year investment period (**Fig. 1**). However, investors do not earn 11.9% with certainty, but face two possible outcomes instead: a 95% probability of earning −100% and a 5% probability of earning 51.0% = $(\$12.3/\$0.2)^{1/10} - 1$. These projects may simply be too risky for most investors given the near certainty of getting wiped out and the long wait before any revenues are generated.

Now consider investing in 150 such programs simultaneously through a single investment vehicle with 150 × $200 million = $30 billion of investable capital, which we shall refer to as a 'megafund'. For simplicity, assume that the success or failure of each program is a statistically independent draw. Then the probability of at least one success among 150 independent programs is $99.95\% = 1 - 0.95^{150}$, which is quite a different proposition. Although the expected profit of each of the 150 programs remains the same at $12.3 billion, the likelihood of at least one hit is dramatically increased, reducing the risk of the entire portfolio. One simple measure of this risk reduction is the s.d. of the annualized return, which is 423% for an individual draw, but only $34.6\% = 423\%/\sqrt{150}$ for the annualized portfolio return. The more risky and less correlated the underlying assets are, the greater the benefits to pooling them, not unlike an insurance pool that provides

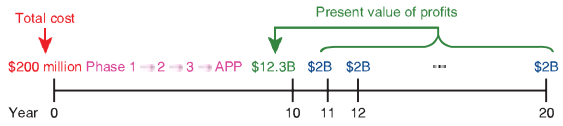

Figure 1 Timeline of cash flow for simplified example of a typical drug-development program in which out-of-pocket costs with present value of $200 million at year 0 generate annual net income of $2 billion in years 11–20, implying a present value of $12.3 billion at year 10 (based on a 10% cost of capital). APP, approval; B, billion.

protection for each of its participants by spreading any given individual's losses over the entire membership. Such pools become more effective as the number of participants increases, and the same is true for megafunds of drug-development projects.

This risk reduction is not costless, but comes at the expense of a much greater capital commitment. Also, unless the individual assets in a portfolio are mutually uncorrelated (which is exceedingly improbable), modern portfolio theory[23] shows that there is a limit to the amount of risk that can be eliminated through diversification. This limit and the optimal size of the megafund depend on several factors, including the pairwise correlations between the assets' returns, the natural scale of the investment in each asset and the risk appetite, expected-return requirements and investable wealth of the population of potential investors. Although some investors may prefer the high-risk/high-return profile of a one-shot drug-development program, there seems to be a much larger pool of investors who prefer the lower-risk/lower-return profile of a portfolio of programs, as suggested by the relative sizes of the venture capital industry ($176 billion) and the mutual fund industry ($11.8 trillion)[24].

Although this example is a caricature of the drug-development process and employs a blockbuster drug metaphor for expositional simplicity (see **Supplementary Analytics** for a nonblockbuster version), it does illustrate one of the key benefits of the megafund structure: the risk reduction from diversification would allow the megafund to issue large amounts of debt as well as equity, greatly broadening the pool of potential investors willing to fund such projects.

To see why, suppose each of the 150 projects was undertaken by a separate company, yielding 150 companies with development costs of $200 million apiece. The all-or-nothing nature of each company's payoff implies that even if a company issued only a small amount of debt, the default probability of such bonds would be 95%. With default nearly guaranteed, debt financing is virtually impossible for these single-project entities, and the riskiness of a single project implies that an initial public-equity offering is also unlikely.

However, a single entity with 150 such programs could issue $24.6 billion of zero-coupon bonds—bonds that pay only one lump-sum payment at maturity—maturing in year 10 with a default probability of only 0.4% (the probability of less than two successes because two hits yield a present value of $2 \times \$12.3 = \$24.6$ billion in year 10, just enough to pay off the bondholders). This default probability is comparable to the historical realized 10-year default rates of the highest-rated category of debt (Aaa) from 1920 to 2010, according to the bond-rating agency Moody's[25]. As of February 2012, Moody's reported the average yield of seasoned Aaa corporate bonds with ~30 years to maturity to be 3.85%[26], which is a reasonable proxy for the yield of a 10-year bond with identical credit quality. At a yield of 3.85%, a zero-coupon bond that promises to pay $24.6 billion in year 10 would generate proceeds of $16.8 billion when issued in year 0. If the remaining $13.2 billion were financed by equity, the expected rate of return and s.d. would be 21.5% and 78.9%, respectively. These values are higher than those of an all-equity-financed case (11.9% and 34.6%) because of leverage, but are still within the range of risk-reward profiles of publicly traded equities. A megafund's ability to issue both debt and equity with attractive terms to a larger pool of potential investors provides greater scale and diversification benefits, yielding greater risk reduction and bigger overall impact on biomedical innovation. Of course, the degree of risk reduction depends entirely on the number of assets in the portfolio and the pairwise correlations of the individual projects' financial returns, which we have assumed to be zero for expositional convenience. Greater correlation reduces the benefits of diversification, and the extreme case of perfect correlation implies no benefits at all. In our simulation study of an oncology megafund described below, we assume pairwise correlations of 20%.

The lower-risk/lower-return profile of a megafund may have little appeal to venture capitalists—especially when compared to an investment in a single compound—but is likely to be of much greater interest to pension funds, insurance companies, money market funds, banks and other large financial institutions, who control a vastly larger pool of investment capital. For example, at the end of 2010 the California Public Employees Retirement System held $226 billion of investable assets, the Norwegian government pension fund held $537 billion and nongovernment US institutional money market funds held $1.1 trillion. Moreover, as of the end of 2010, the total size of the US bond market was $35.2 trillion. In relation to these magnitudes, a megafund of $30 billion no longer seems as unattainable if debt-financing is feasible.

Of course, the required size of a megafund is determined by many factors as we show in our simulation study below, and although our simple portfolio example adopts the standard blockbuster revenue model, neither that analysis nor the simulation results hinge on discovering blockbusters (**Supplementary Analytics**). This is especially important in light of recent challenges to the blockbuster revenue model from changes in patent laws, payer reimbursement policies and the discovery of biomarkers that reduce the population of patients for certain drugs[20,27]. Portfolio theory applies to any level of drug development, and its effectiveness is determined by the combination of expected revenues, probability of success and correlations among drug-development programs, not by the scale of the portfolio's assets.

We have grossly oversimplified the economics of the biopharma industry in the above example to provide intuition for the mechanism by which investment performance can be enhanced through diversification. The main results of this paper consist of a detailed multiperiod simulation of an oncology megafund that reflects more realistic features of the drug-development process, including correlation among assets, stochastic transitions from one phase to the next over time and realistic valuations of compounds that are sold during intermediate stages of the clinical trials process. Before turning to these results, we first address the challenge of raising large amounts of capital, which may seem impractical given recent corporate consolidations, budget cutbacks and capital scarcity[28]. This challenge can be met by the second component of our framework: securitization.

Securitization

Given the scale of financing needed for creating a truly diversified portfolio of drug-development investments and the time lag between capital commitment and return, private-partnership structures, such as venture capital, may not be the best source of funding for this industry. Instead, we propose tapping public capital markets directly through securitization[14], a common financing method in which investment capital is obtained from a diverse investor population by issuing debt and equity securities that are claims on a portfolio of assets—in our case, biomedical research. A common form of securitization involves 'cash-flow' transactions in which a portfolio of assets—typically mortgages, auto loans, student loans or credit-card receivables—is acquired using money raised by issuing equity and bonds of different seniorities. These assets and the cash flow they generate are pledged as collateral for the debt.

In our proposed application, the assets include the initial capital raised from investors, all the subsequent biomedical R&D and licenses acquired, and all the profits generated by these activities or through sales of these assets in later periods. The application of securitization

to early-stage clinical and preclinical biomedical assets has not been described previously, and we shall refer to debt that is collateralized by such assets as 'research-backed obligations'.

To ensure that the portfolio of assets is used only to satisfy the payments of the newly issued research-backed obligations, the megafund forms a stand-alone legal entity called a 'special-purpose vehicle' for the express purpose of purchasing the collateral and issuing and servicing the securities. Equity holders own equity in the special-purpose vehicle and thus have a claim on the residual assets and cash flow that remain after all debt obligations have been satisfied. The special-purpose vehicle is managed by a separate management company, but for simplicity we shall refer to both the special-purpose vehicle and the management company that structures the biomedical R&D acquisitions and licensing deals as the megafund.

To provide different levels of risk and expected return for the broadest possible set of potential investors, the megafund divides research-backed obligations into distinct classes or 'tranches' with different repayment priorities. The senior tranche has highest priority, meaning that in each payment period its obligations must be satisfied first before those of any other tranche, and each of the more junior tranches are repaid in order of their priority. In the event that the assets do not generate sufficient cash flow to make all promised payments to bondholders in any given period, the senior-most tranche will be paid first, followed by the next most senior tranche and so forth, until the available cash is exhausted. Therefore, the senior tranche is the least likely to experience losses; thus, it will have the lowest risk and offer the lowest yield, which appeals to the most risk-sensitive investors such as money market funds, banks and smaller pension funds.

More junior tranches have higher loss probabilities and must offer correspondingly higher yields to compensate investors for this increased risk, which attracts more risk-tolerant investors such as large pension funds, endowments and high-net-worth private investors. The most junior tranche is often structured as equity—and sometimes called the 'equity tranche'—with no promised payments whatsoever but with unlimited upside potential once bondholders are repaid in full.

Equity holders stand to reap the biggest gains if the megafund's underlying assets do well, but they are the first to suffer losses if those assets are not profitable. As a result, this is the riskiest tranche and is likely to be purchased by the most risk-tolerant portion of the investor population (that is, hedge funds, funds of funds and deep-pocketed institutional investors including large endowments and pharmaceutical companies). The size and order of the tranches is known as the special-purpose vehicle's 'capital structure' and the motivation for multiple tranches should now be clear: regardless of how risk averse or risk seeking an investor is, there is likely to be a particular tranche of this special-purpose vehicle's debt issue that will satisfy the investor's risk preferences.

In addition to the different levels of priority, research-backed obligations can be customized in several important ways. For example, they can be structured to have varying maturities ranging from short term (to appeal to more impatient investors like commercial banks and money market funds) to long term (to appeal to pension funds, endowments and sovereign wealth funds). By providing the desired maturity for each type of lender, research-backed obligations may appeal to a broader cross-section of investors while reducing the shorter-term pressures of generating earnings and preparing for an initial public-equity offering, which can often lead to the distressed sale of promising but early-stage assets. Typical securitizations employ debt maturities of 15 years or less; for example, in August 2007, DRI Capital (Toronto) issued $356 million of 8- and 15-year bonds backed by major royalty rights to the FDA-approved biopharmaceutical products Enbrel (etanercept), Remicade, PREOS (preotact) and FluMist (trivalent live attenuated influenza vaccine).

Additional features known as 'credit enhancements' and 'triggers' are often used to provide further protection for the research-backed obligations' most senior tranches. These features include default insurance through credit-default swaps, over-collateralization, the use of interest- and debt-coverage ratio thresholds that trigger accelerated payments when breached, and government guarantees and tax incentives (**Supplementary Methods: Credit Enhancement**).

The special-purpose vehicle's capital structure, priority of payments and various coverage tests and credit enhancements are collectively known as the 'cash flow waterfall'—a reference to the manner in which cash flow from the special-purpose vehicle's assets spills over from senior to junior tranches—which fully determines the financial structure of each of its corresponding securities and how investors will be compensated in all circumstances (**Fig. 2**).

Once the special-purpose vehicle's cash flow waterfall is specified, the economic value of the securities it issues can be directly related to the performance of its assets. If the statistical properties of the cash flow of each of those assets can be quantified, the risk-reward profile of the special-purpose vehicle can be estimated, its securities can potentially be rated by bond-rating agencies and these securities can be evaluated and purchased by a broad universe of investors. Therefore, one of the key factors in determining whether a pool of assets can be securitized is whether the stochastic properties of the underlying assets' returns over time can be measured and managed. In the multi-trillion-dollar mortgage-backed securities market, the answer was (and still is) yes, as is the case for corporate debt and several other asset classes[29]. We believe the same may be true for biomedical research. By creating a large portfolio of well-diversified biopharma investments and by spreading the risks and rewards of such a portfolio across a much larger and more diverse group of investors through securitization, it may be possible to facilitate large-scale and long-term biomedical innovation in a sustainable and, ultimately, profitable manner.

A cancer megafund as an illustrative example

To illustrate the practicality of megafund financing, we present a detailed simulation of a hypothetical funding vehicle for cancer drug

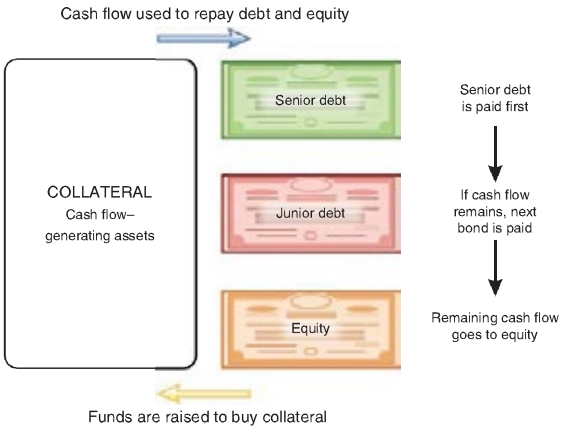

Figure 2 Schematic of the waterfall of cash flow for a typical research-backed obligation securitization.

development programs. Our focus on cancer is motivated by three considerations. First, cancer is a leading cause of death. The lifetime probability of developing cancer in the United States is 1 in 2 for men and 1 in 3 for women[30], and the number of deaths caused by cancer worldwide will grow to over 12 million per year by 2030 (ref. 31), creating an urgency and visibility that will greatly facilitate fundraising for a cancer megafund. Second, because cancer is a complex group of over 200 diseases, the multiple approaches to anticancer therapies yield greater opportunities for portfolio diversification, offsetting to some degree the megafund's singular focus on cancer. And finally, several comprehensive databases of cancer drug-development programs exist, allowing us to construct more realistic simulations of the possible risks and returns from a cancer megafund. These simulations are critical for capturing the complexities of the oncology drug development process and for communicating the megafund's risks and rewards to potential investors, a prerequisite of any successful fundraising effort.

These motivations must be tempered by the caveat that a megafund devoted solely to cancer is likely to understate the benefits of diversification and megafund financing for at least two reasons: the unavoidable correlation among cancer drug discovery programs due to common biochemical pathways and pathologies, and the fact that since 2004 cancer-drug approval rates have been the lowest among all therapeutic areas (6.7% in oncology versus 12.1% in all other areas combined as of 2011; ref. 32). A more effective approach would be to target many diseases in addition to cancer so as to increase diversification. Moreover, our simulation focuses exclusively on the development of anticancer compounds, which ignores several other important facets of cancer care, such as diagnostic tools, radiosurgery and gene therapy for which we have much less historical data to draw on.

As with any simulation, each of our parameters can be challenged as being too conservative or too optimistic, and our hypothetical business structure may be viewed as too simplistic. We acknowledge these concerns at the outset and encourage readers to experiment with our simulation software using their own calibrations (our complete source code is available in both R and Matlab under an open-source license that enables all researchers to use, modify and distribute it).

For concreteness, the financing mechanism we consider in this illustration relies on the securitization of experimental drug compounds only, and the objective of the special-purpose vehicle would be to finance the development of each of its compounds while satisfying the megafund's obligations to its bondholders and providing attractive returns to its equity investors. The business structure of the special-purpose vehicle is illustrated in **Figure 3**, and the types of payments made by the special-purpose vehicle during its life include the following.

Startup expenses and purchases. The special-purpose vehicle will deploy its initial capital by acquiring economic rights to anticancer compounds in exchange for upfront and milestone payments as well as funding R&D and clinical trials (see **Supplementary Methods: The Drug Approval Process** for a summary of the clinical trials process).

Initial post-launch expenses and principal and interest. Because it may take several years before its investments begin generating revenues, the special-purpose vehicle will set aside an initial cash reserve to fund clinical trials for its portfolio of compounds during the life of the transaction. These reserves will also ensure that timely payments of interest can be made on the research-backed obligations.

Ongoing R&D and financing expenses. The special-purpose vehicle will pay for ongoing R&D expenses of its portfolio assets during the life of the megafund. As part of this process, the special-purpose vehicle may decide to sell some of its assets and engage in other corporate transactions to realize gains, meet funding needs or for strategic reasons.

Management costs. During each year, the special-purpose vehicle will pay salaries to its staff, fees to external service providers and other operating costs that are part of the management fee, which is typically assessed as a fixed percentage of the special-purpose vehicle's total assets under management.

Sale of portfolio. Upon the maturity of the longest-dated research-backed obligation, the special-purpose vehicle portfolio will be liquidated and the proceeds paid out to the equity holders.

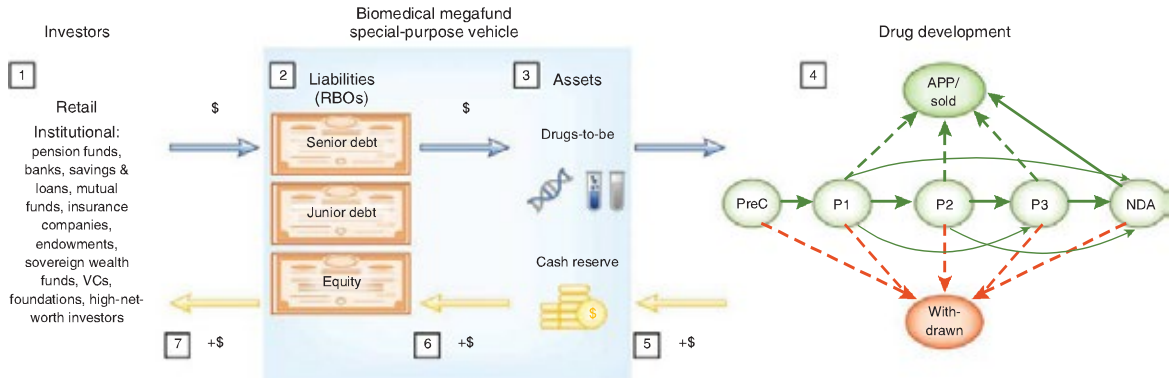

Figure 3 Business structure of a biomedical megafund special-purpose vehicle. Funds are raised from retail or institutional investors (1) through the capital markets issuance (2) of various types of debt and equity. These funds are invested in molecules being developed to cure cancer (3). Some funds are reserved to pay for later clinical development costs and, if required, to cover the first few periods of coupon payments. The portfolio of drugs is developed over time (4). At any time a compound can be discontinued or move to the next or subsequent phases, based on the results of the trials. It is also possible that compounds can be sold before their FDA approval for marketing if it is necessary to monetize them to cover some of the fund interest or principal payments. Any compound that is approved for marketing as a new drug is sold to a biopharma company. At the end of the life of the fund, all remaining compounds in the portfolio are sold (5). After bondholders are paid back (6), the residual cash is used to pay back the equity holders (7). VC, venture capitalist; RBO, research-backed obligation; PreC, preclinical; P, phase; NDA, new drug application; APP, approval.

Table 1 Summary of valuation and cost assumptions for the biomedical megafund simulation[a]

Parameter	Preclinical	Phase 1	Phase 2	Phase 3	NDA	Approved
Compound valuation assumptions ($ millions)						
Mean	16	30	82	425	1,515	1,870
Max.	100	250	500	1,000	2,500	5,000
Lognormal mean	2.4	3.0	4.0	5.8	7.4	7.2
Lognormal s.d.	0.9	0.9	0.9	0.9	0.9	0.9
Pairwise correlation	0.2	0.2	0.2	0.2	0.2	0.2
Investment assumptions ($ millions)						
Upfront	2.5	7.5	20.1	75.2		
Milestone	1.3	3.8	10.0	37.6		
Development cost assumptions ($ millions)						
Mean expected cost	6	19	50	188		
s.d. cost/phase	6	16	47	132		
Max cost/phase	20	50	120	500		
Lognormal mean	1.5	2.7	3.7	5.1		
Lognormal s.d.	0.8	0.7	0.8	0.6		

[a]The means and s.d. of the lognormal distribution of costs and valuations were calibrated based on published studies and public databases; details are provided in **Supplementary Methods: Simulations.**

Our analysis involves simulating the revenues and costs in each period during the life of the special-purpose vehicle as compounds advance through the R&D and approval process. We use historical industry values that are summarized in **Table 1** and derived from various research studies and data from financial information and news provider Bloomberg (New York)[4,33–35]. To calibrate the simulation of the clinical-trials process, we merged two data sets: the DEVELOPMENT optimizer database provided by Deloitte Recap (San Francisco) and a data set provided by the Center for the Study of Drug Development at Tufts University School of Medicine (Medford, MA, USA). The merged data contained over 2,000 compounds that, after removing duplicates and compounds for which there was not enough information, yielded a final set of 733 new molecular entities developed primarily for anticancer indications that entered clinical trials between January 1990 and January 2011. These compounds were developed by biotech or pharmaceutical companies and were either therapeutic compounds or vaccines (summary statistics for the data are provided in **Supplementary Methods: Simulations**). Using these data and the results of Paul *et al.*[4], we define seven distinct phases of drug development—the initial preclinical phase, the three stages of the clinical-trials process (phases 1, 2 and 3), new drug application, approval and withdrawal—and estimate the transition probability matrix P given in **Table 2** using standard statistical methods (**Supplementary Methods: Simulations**).

Using this transition matrix and assumptions regarding the revenues, costs and correlations of the drug-development process—summarized in **Tables 1** and **3**—we performed two simulations labeled 'Simulation A' and 'Simulation B' (**Fig. 4**). Both simulate a series of six-month periods during which compounds are either withdrawn, sold or advance to the next clinical stage depending on whether or not they achieve various milestones. Simulation A corresponds to early-stage investments in compounds that begin in the preclinical phase, which—if they are not sold for other reasons earlier—are sold when they transition to phase 2. Simulation B corresponds to later-stage investments in which compounds are acquired in phase 2 and sold when they are FDA approved. This division acknowledges the major scientific and business differences between early-stage investments, which are typically the domain of venture capitalists, and later-stage development typically undertaken by large biotech or pharma companies that license compounds predeveloped by smaller biotech companies and finance their development until discontinuation or approval by the FDA. By conducting two separate simulations, we are implicitly allowing different sets of investors to participate during different phases of the drug-development process. This structure permits the maturities of the bonds to be much shorter than would be the case if compounds were funded by the same investors throughout the full cycle from preclinical development to FDA approval, which can often exceed a decade. Full-cycle simulations can also be performed within our framework. Taken together, the two simulation experiments performed in this paper provide a compelling case for megafund financing throughout the entire drug-development cycle.

The simulation experiments are done in pairs, each pair consisting of a traditional all-equity fund—similar to a venture capitalist or mutual fund—versus a matching research-backed-obligation structure with a senior tranche, a junior tranche and an equity tranche, where the size of the equity investment is the same in both (we use three tranches only for expositional simplicity; in practice, more tranches could be offered). Unlike the simplified example above, in which we assumed that the cash flow from each drug-development program in the portfolio was uncorrelated, our simulations impose a more realistic 20% positive correlation between the valuations of all pairs of compounds to capture the potential for the clustering of negative outcomes in any given period (**Supplementary Methods: Simulations**).

Table 4 contains the results of a megafund with $5 billion of initial capital invested over 7.5 years in a target portfolio of 100 preclinical and 100 phase-1 compounds, with a $1.25-billion senior tranche, a $1.25-billion junior tranche and a $2.5-billion equity tranche, implying a modest leverage ratio of 2-to-1 for the special-purpose vehicle. In a simulation consisting of 500,000 independent sample paths, an average of 102 compounds reached the goal of entering phase 2. As, historically, there is a very small but nonzero probability of transitioning from phase 2 to phase 3 in less than one semester (e.g., due to concurrent trials), the transition matrix P allowed for this possibility and the simulations generated a small number of compounds that

Table 2 Transition probability matrix for simulating the clinical trial process (in percent)

	$PreC_{t+1}$	$Phase\ 1_{t+1}$	$Phase\ 2_{t+1}$	$Phase\ 3_{t+1}$	NDA_{t+1}	APP_{t+1}	WD_{t+1}
$PreC_t$	50.0	34.5	0.0	0.0	0.0	0.0	15.5
$Phase\ 1_t$	0.0	80.8	13.3	0.5	0.0	0.0	5.3
$Phase\ 2_t$	0.0	0.0	84.5	6.7	0.3	0.1	8.5
$Phase\ 3_t$	0.0	0.0	0.0	84.8	6.8	2.1	6.3
NDA_t	0.0	0.0	0.0	0.0	56.7	41.2	2.2
APP_t	0.0	0.0	0.0	0.0	0.0	100.0	0.0
WD_t	0.0	0.0	0.0	0.0	0.0	0.0	100.0

Details are provided in **Supplementary Methods: Simulations.**
PreC, preclinical; phases 1–3; NDA, new drug application; APP, approval; WD, withdrawal; time subscript t indicates current six-month simulation period and t+1 indicates the following six-month simulation period. Entries in each row may not sum to 100% due to rounding.

Table 3 Additional parameters of the biomedical megafund simulation

Parameter	Assumed value in simulation
Time	
Tenor of the research-backed obligation	7.5 years (15 semesters)
Time to deploy capital	1 semester
Time to sell each compound	2 semesters
Capital structure	
Total amount of capital	$2.5–15 billion
Tranches	Senior bond, junior bond, equity
Leverage	2 or 2.5 times
Bond annual yield	Senior bond 5%, junior bond 8%
Redemption senior bond	Equal semiannual installments from semester 5 to 8
Redemption junior bond	Equal semiannual installments from semester 9 to 12
Cash-out equity	Period 17
Investor protection rules	
Interest coverage test	Senior debt (2), junior debt (3 or 3.5)
Cash reserved at start	To cover 2 periods of interest and expected drug development costs
Other	
Number of compounds per fund	Between 40 and 200
Equity ownership of each asset	85%
Research-backed obligation service fee	0.5% per year of total assets under management
Return on excess cash	1% per year

See **Supplementary Methods: Simulations**, for details.

reached phase 3, new drug application and approval before the end of the life of the fund.

The results in **Table 4** show that the megafund is almost always profitable. The senior-tranche research-backed obligation investors received an annual coupon payment of 5% and were repaid in full 99.9% of the time, which is comparable to historical default rates of the highest-rated bonds according to Moody's and Standard & Poor's[25,36], the two largest bond-rating agencies in the financial industry. Junior-tranche research-backed obligation investors were paid an annual coupon payment of 8% and repaid in full 99.1% of the time. Finally, equity-tranche investors received an average annual return of 8.9%, and in over a third of the simulated sample paths their average annual return exceeded 15%. Although such returns may not be sufficiently attractive to traditional venture capitalist investors, large institutional investors such as pension funds, insurance companies and endowments are likely to show more interest. Recall that unlike venture-capital funds and all-equity structures where the possibility of substantial or total loss can be nontrivial, the megafund structure offers both debt and equity—risk-seeking investors can purchase the latter and more conservative investors can participate through the former. Because there are substantially larger pools of conservative investment capital, research-backed obligations allow the biopharma industry to greatly expand its drug-development efforts by tapping into this tremendous asset base. In fact, certain types of financial institutions may find research-backed obligations especially attractive either because they serve as natural hedges to existing business risks, such as annuity providers (whose costs increase when people live longer), or because their corporate mandate is to support socially relevant activities but precludes them from investing in equity (in which case, they can now invest a portion of their endowment's assets in research-backed obligations rather than just awarding grants from the annual interest on those assets).

The higher risk of the equity tranche is accompanied by the benefits of leverage provided by the bond issue, which allows the special-purpose vehicle to invest in a larger and more diversified portfolio of assets. This effect can be quantified by comparing the results of the equity-and-debt case with the all-equity simulation, in which the special-purpose vehicle contains the same amount of equity capital ($2.5 billion) but no debt (**Table 4**). In the all-equity simulation, the megafund invests in 50 preclinical and 50 phase-1 drugs, successfully carrying 52 to phase 2 and generating an expected annualized return of 7.2%. The fact that this is lower than the 8.9% return in the research-backed obligations case is explained by the correspondingly lower risk of the less-leveraged portfolio (note that the probability of a negative return is 17% in the all-equity case and 20% in the research-backed obligations case).

In simulation B, compounds are acquired in phase 2 and each can transition to its next development phase, be discontinued or be sold. Any compounds that are approved for the market are automatically sold. **Table 4** presents the results of 500,000 independent simulated sample paths of a megafund with $15 billion of initial capital invested over 7.5 years in a target portfolio of 100 phase-2 compounds. The capital structure consists of a $6-billion senior tranche (with 5% yield as in simulation A), a $3-billion junior tranche (with 8% yield), and a $6-billion equity tranche, implying a 2.5-to-1 leverage ratio. On average, the simulation yielded just under 8 compounds approved for sale and over 21 compounds advanced to phase 3 or new drug application (because they did not have time during the life of the fund to reach market approval or were sold to finance principal and interest payments to bondholders). The investment performance of this special-purpose vehicle is even more attractive than the early-stage simulation. Senior-tranche research-backed obligation investors were repaid in full 99.9% of the time, junior-tranche investors were repaid in full 99.4% of the time and equity-tranche investors received an average annual return of 11.4%, which compares favorably with the results offered by the equity-only fund. In fact, an equity-only fund with the same equity capital ($6 billion) would finance the development of 40 phase-2 drugs, with only 6 advancing to phase 3 or new drug application, 5 to market and offering investors an expected annualized return of only 7.2%.

Will rates of return of 8.9–11.4% for equity and 5–8% for debt attract capital of $5–15 billion as we have assumed in these simulations? The answer depends on the type of investor. Such returns may be of little interest to the private-equity and venture capital community, but for more conservative and larger institutional investors, such as pension funds, insurance companies, money market and mutual funds, endowments, foundations and trusts, these returns may be more compelling.

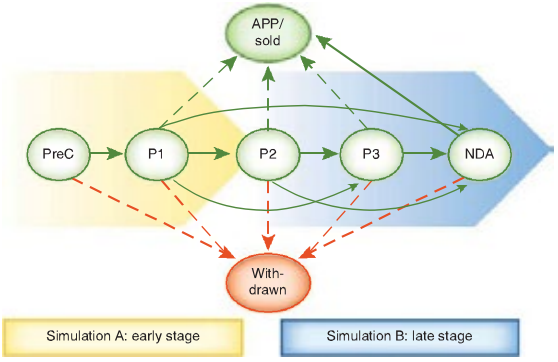

Figure 4 Simulating two distinct business stages of a biomedical megafund. PreC, preclinical; P, phase; NDA, new drug application; APP, approval.

Table 4 Performance summary statistics of the biomedical megafund simulations

	Simulation A		Simulation B	
Variable or summary statistic	All equity	Research-backed obligations	All equity	Research-backed obligations
Number of compounds				
Preclinical	50	100	—	—
Phase 1	50	100	—	—
Phase 2	—	—	40	100
Phase 3	—	—	—	—
Research impact				
Number of compounds to reach phase 2	52.8	101.7	—	—
Number of compounds sold in phase 3 and NDA	0.9	2.3	6.0	21.3
Number of compounds sold once APP	0.6	1.0	5.1	7.6
Liabilities				
Capital ($ millions)	2,500	5,000	6,000	15,000
Senior tranche ($ millions)	—	1,250	—	6,000
Junior tranche ($ millions)	—	1,250	—	3,000
Equity tranche ($ millions)	2,500	2,500	6,000	6,000
Equity tranche performance				
Average annualized return on equity	7.2%	8.9%	7.2%	11.4%
Prob. (return on equity < 0)	17%	20%	17%	10%
Prob. (return on equity > 5%)	61%	68%	63%	79%
Prob. (return on equity > 15%)	15%	35%	14%	40%
Debt tranches performance				
Senior tranche: default prob., expected loss (bp)	—	1, <1	—	6, <1
Junior tranche: default prob., expected loss (bp)	—	87, 27	—	60, 30

bp, units of basis points or 0.01%; prob., probability.

To see why, consider the fact that the median rates of investment return of public pension fund assets over the 5-, 10-, 20- and 25-year periods ending 31 December 2011 were 2.0%, 5.7%, 7.7% and 8.3%, respectively[37]. Moreover, in a July 2012 survey of 126 state and local government pension funds, the median target investment return was 8.0%[37]. This number represents more than just a survey response—it is incorporated as an actuarial assumption that affects a pension fund's investment and pension-benefit decisions; hence a target return of 8.0% is a relevant hurdle rate for such institutions, which account for $3 trillion in investable assets as of the first quarter of 2012 (ref. 37). Of course, institutional investment decisions also depend on other characteristics besides return potential, such as risk and correlation to broadly diversified stock and bond portfolios (which are the vast majority of these institutions' holdings). These considerations are precisely the motivation for offering multiple tranches, each with a different risk-reward profile. One of the primary advantages of securitization over more traditional methods is the ability to customize financing arrangements to suit the particular characteristics of the assets and investors (e.g., more tranches, staggered debt maturities, permanent equity and payments that are contingent upon reaching certain research milestones). Greater customization implies a broader population of investors for which these customized securities may be appropriate investments.

Of course, our simulation results depend on our choice of simulation parameters, which represents just one of many possible sets of assumptions. To allow readers to evaluate the feasibility of megafund finance under their own preferred scenarios, we have placed our simulation software in the public domain with an open-source license to run, modify and distribute the code (**Supplementary Software**).

DISCUSSION

Despite the promising simulation results for oncology compounds, any implementation of megafund financing must overcome several practical challenges. In this section, we provide a brief summary of these challenges and some possible solutions (for a more detailed discussion, see **Supplementary Discussion**).

The challenges of implementing megafund financing can be loosely grouped into two broad categories: raising capital and deploying capital. The feasibility of raising billions of dollars for biomedical applications is predicated on the ability of investors to assess the risk-reward trade-offs of the investments. Historical biopharma data may not be an accurate guide to the future because of the rapidly shifting landscape of translational medical research and its economic implications for the industry. However, the inability to accurately predict translational research outcomes does not imply an inability of investors to assess the financial risks of and commit capital to a diversified portfolio of such outcomes. The changing nature of biomedical innovation can be complemented by changing the nature of the corresponding funding vehicles—greater risk, even unknown risk, can often be managed effectively through more sophisticated financial engineering.

A less obvious but equally important concern is that megafund financing works too well. In addition to their potentially attractive risk-reward profiles, biomedical megafunds are naturally positioned to benefit from the 'socially responsible investing' trend in the financial industry. This growing trend is a powerful force that could quickly turn a niche product into a cottage industry. The rapid growth and subsequent crash of the US mortgage-backed securities markets has provided us with several important lessons for managing this potential boom-or-bust pattern. Rules regarding sales practices, disclosure requirements, permissible corporate governance structures and suitability criteria for investors must be imposed and strictly enforced to ensure that megafunds serve their purpose without jeopardizing the stability of the financial system.

Deploying megafund capital is likely to pose a greater challenge than raising capital, especially if capital is raised quickly. There are at least four elements to this challenge that require further investigation. The first is whether academia and the biopharma industry have

sufficient physical and intellectual capacity to make use of megafund capital. The second is whether the market for compounds, licenses and royalties will become sufficiently deep and liquid to generate enough cash flow to service megafund debt. The third is whether any single organization can successfully manage the complexity of a megafund portfolio. And the fourth is whether the political and regulatory environment—including healthcare reform and the FDA approval process—will support the kind of innovation implied by megafund financing.

We believe that all four of these challenges can be met.

With respect to capacity, based on published research as well as informal discussions with academic and industry insiders, it is clear that there are more innovative ideas, graduate students and professionals in biomedical research than there is funding to support them.

With respect to the secondary market for biopharma projects, the recent experience of the mortgage-backed securities industry suggests that market depth and liquidity are highly correlated with asset growth; if tens of billions of dollars flow into biomedical megafunds, that alone is likely to enhance secondary market activity substantially.

With respect to the organizational complexities of megafund management, as financial economists and biopharma-industry outsiders, we are not qualified to judge the feasibility of this endeavor. Even so, the fact that the leading drug-royalty investment company, Royalty Pharma, manages $8 billion in assets with a full-time staff of only 19 professionals (albeit with the support of a much larger network of biomedical experts as consultants) suggests that managing a $30-billion megafund is not impossible. Moreover, size confers benefits as well as costs, including economies of scale and scope, research synergies, greater stability, staying power and marketing clout.

Finally, with respect to the political and regulatory environment, given the current climate of political deadlock, a concerted effort by the private sector to reduce the burden of disease may be one of the few initiatives capable of generating truly bipartisan support. In the same way that other markets have benefited from various forms of government support, a biomedical megafund should be an attractive cause for ambitious politicians to adopt.

One final challenge facing the megafund that involves neither raising nor deploying assets has to do with the inherent conflict between the business culture and the world of science and medicine[2]. This conflict is not new to megafunds but has existed since the very beginning of the biotech industry. However, the sheer size of a megafund may magnify these conflicts to an unsustainable level.

The combination of social relevance and the profit motive may seem confusing and inappropriate to some, but this trend is becoming more prevalent as we face societal challenges that require an unprecedented scale of collaboration among millions of individuals. Although charitable giving is an important part of translational medical research, the magnitude of such giving is dwarfed by the pool of investment capital seeking a reasonable rate of return. By creating financial incentives for solving social problems like cancer, society is able to tap into this much larger pool of assets.

The megafund can be viewed as another example of the broader trend toward 'venture philanthropy' as practiced by existing organizations, such as the Gates Foundation (http://www.gatesfoundation.org/), the Robin Hood Foundation (http://www.robinhood.org/) and the Children's Investment Fund Foundation (http://ciff.org/). Another form of this trend is public-private investment programs, in which private-sector institutions provide financing under certain types of government sponsorship. Such programs played an important role in dealing with the recent financial crisis by raising over $29 billion of investment capital to purchase distressed securities[38]. Several important government initiatives are already under way for speeding up translational medical research, such as the US government's National Center for Advancing Translational Sciences (which is part of the Cures Acceleration Network) and the Israeli Life Sciences Fund. But with budgets of only $575 and $200 million, respectively, these efforts will eventually also require substantial private-sector funding—megafunds may be one solution.

In conclusion, cancer is just one of a growing number of large-scale challenges confronting modern society that can be addressed only through the sustained collaboration of thousands of highly skilled, dedicated and independent individuals over many years. Financial engineering methods, such as portfolio theory and securitization, facilitate such complex collaborations by providing appropriate financial incentives to all stakeholders. Although altruism and charitable giving are important elements in responding to these challenges, we cannot rely solely on these motivations given the scale of the problems to be solved. By structuring biomedical research funding in a research-backed obligation format, incentives to reduce the burden of disease are distributed to a much broader community of stakeholders. As a result, much greater resources can be marshaled to take on such challenges which, in turn, will attract leading experts to join the effort, instilling even more confidence among investors, and so on. Such a virtuous cycle can greatly magnify a megafund's likelihood of success.

Our proposed application of securitization may be untested, but the techniques are used extensively in the financial industry. Some of these uses involve mortgage-related securities that played a central role in the recent financial crisis, which has created a backlash of skepticism and distrust among certain investors and issuers. However, rather than shying away from such techniques because of the crisis, a more measured response may be to acknowledge their strengths, address their weaknesses and use them wisely to meet the most pressing social challenges. Despite the lack of consensus regarding the ultimate causes of the financial crisis, its magnitude provides compelling evidence that with the proper incentives and financial structure, securitization is a highly effective means of gathering large amounts of capital in a relatively short period of time. If used responsibly, these tools could play a transformative role in many other socially important initiatives.

Proposing to raise billions of dollars for biomedical research in the current economic climate may seem ill-timed and naive. However, today's low-interest-rate environment is, in fact, ideal for issuing long-term debt, and investors around the globe are desperately seeking new investment opportunities that are less correlated with traditional asset classes. More importantly, the cost in terms of burden of disease—as measured by the more than half a million people expected to die of cancer this year in the United States alone or the $263 billion in estimated economic impact[30]—must be balanced against the risk of failure. Similar trade-offs exist for other grand challenges of this century such as flu pandemics, climate change and the energy crisis. Instead of asking whether we can afford to invest billions more at this time, perhaps we should be asking whether we can afford to wait.

Requests for software. jose-maria.fernandez@sloan.mit.edu.

Note: Supplementary information is available in the online version of the paper.

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AUTHOR CONTRIBUTIONS

All authors contributed equally to this research. A.W.L. first developed the idea for securitizing biomedical research after conversations with J. Broderick in March 2007 about a portfolio approach to biomedical innovation. A.W.L. assembled key members of the project team, provided funding through the MIT Laboratory for Financial Engineering and was responsible for overall project management. J.-M.F. was responsible for coordinating all aspects of the project, including directing research assistants, obtaining and processing all input data, calibrating the simulation parameters, running the simulations, and preparing the initial draft of the manuscript, with input and oversight from A.W.L. and R.M.S. R.M.S. developed the analytic framework for modeling the portfolio of drug compounds. R.M.S. and L. Han developed the R code with assistance from J. Noraky and J.-M.F., and input from A.W.L. and A. Singhal. A. Bernard converted the R code to Matlab. A.W.L. and J.-M.F. validated the final version of the Matlab code. R.M.S. also prepared the description of the simulation results, which was reviewed and revised by J.-M.F. and A.W.L. A.W.L. constructed the illustrative portfolio example and prepared the final draft of the manuscript, with input and revisions from J.-M.F. and R.M.S.

COMPETING FINANCIAL INTERESTS

The authors declare competing financial interests: details are available in the online version of the paper.

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Breakout session 2

"How do university innovation initiatives fit into the broader early stage financing environment?"

Group's background information:

Bridging the gap between early stage promising innovations to attractive commercialization assets

TEL AVIV UNIVERSITY

Technology Innovation Momentum Fund

suggested funding model

RAMOT | TAU
promising innovations

STRATEGY, STRUCTURE and STATUS

Structured as an off shore Limited Partnership to provide a return to its founding investors and TAU.

Special tax ruling in Israel for 100% tax exemption for any revenues generated by the fund. Annual investments will be reported as an expense!

Investments in multiple on-going research projects in various amounts, pending the path to commercialization, on the basis of stringent, industry-grade criteria.

Managed by Ramot, on behalf of the Partnership, the dedicated business development and technology transfer arm of TAU. **No management fees will be charged.**

First round of investment ended with 6 selected technologies

Second round of investment is expect in Q42014. Currently about 15 proposals made it to the Scientific Committees

RAMOT TAU promising innovations

REVENUE DISTRIBUTION

- The Partnership will allocate all revenues earned between the Partnership and TAU.
- Until a return of 200% of the Momentum Fund's investment, these revenues will be shared on a 50%/50% basis by the Momentum Fund and TAU.
- Subsequently , the Momentum Fund Partnership will keep 40% of such revenues and TAU will receive 60%.
- TAU will distribute its portion of such revenues: 40% to the inventor / inventors, 20% for the research and 40% to TAU

4

RAMOT TAU promising innovations

MF – Academic Researcher's Benefits

- The project is carried on at the academic scientist's natural environment
- The academic scientist continues his regular duties including PhD/MSc student supervision, publishing, etc.
- The scientist gets at least 25% of the total financial benefits
- The projects are selected based on proven IP and clear commercial potential. Thus, there is a full financial alignment of interest between the financial sponsors and the scientist
- The projects benefits from professional business development and project management support from RAMOT
- MF investor portfolio includes strategic corporates that could accelerate the business development activity of the project

5

RAMOT TAU promising innovations

LEAD INVESTOR - TATA

India's **largest** business group

with business in **seven** sectors

and operations in over **80** countries;

and over **456,000** employees.

Group revenue of **$ 100.09 bn**;

58% in geographies other than India.

6

RAMOT TAU promising innovations

PROJECTS SELECTION AND FUNDING

Three scientific committees will cover the diverse areas of potential investments:

The scientific committees will make investment recomendations, supervise the milestone based progress of the different investments on a quarterly basis as well as provide business guidance and industry connections

Qualified Partnership Investors and or their representatives may participate in the different scientific committees to enable hands-on involvement and contribution

RAMOT TAU promising innovations

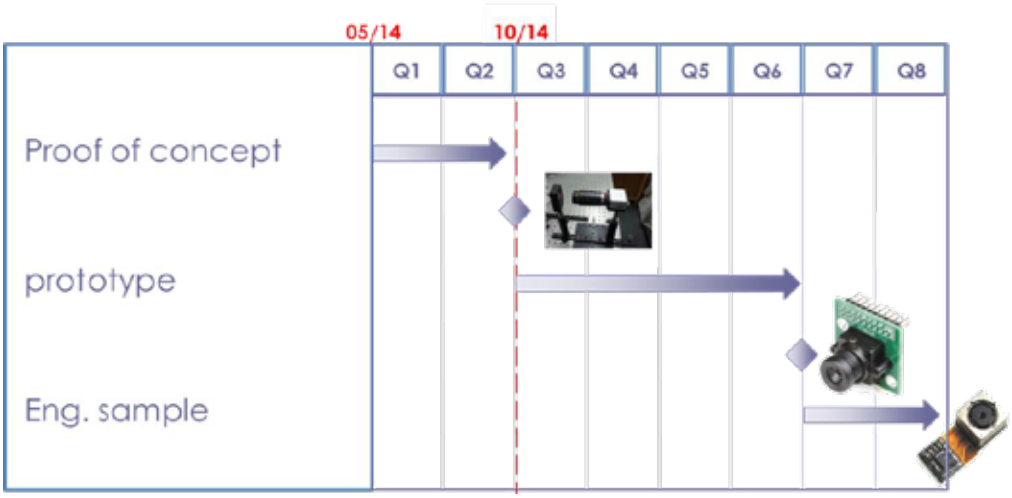
Licensing based Venture Vs. Venture Capital & PE

	Licensing Venture Momentum Fund	VC & PE
Investment Model	Non-Dilutive Cash flow based investment	Dilutive equity investment
Ownership %	50%	~25%
Management Fees	None	~2% - 4%
Exit Strategy	Annuity stream during 15-20 years period	Exit events
Investment Nature	Robust IP Based	Mix / Shorter term horizon
Diversification	Wide	Selected fields – Narrow
IP	Full ownership	No IP ownership
Strategic Partner	Tata Group Companies	None

RAMOT TAU promising innovations

An example of MF Project: SIS – Smart Image Sensor

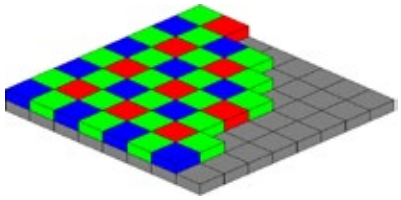
Timeline



RAMOT | TAU
promising innovations

Vision Statement

Resolving the main pains of present cameras by replacing the standard 38-years-old color sensing mechanism.



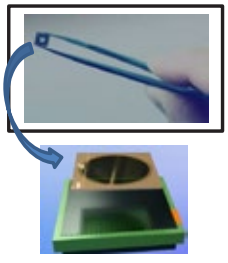
US patent “Color imaging array”, published on July 20, 1976
B.E. Bayer

US provisional patent application “A system and method for color image acquisition”, filed on June 24, 2013

The result: 4 times more resolution, stabilized image, enhanced color fidelity and improved low-light performance.

Two Principles

Multi exposure: Few exposure with different optical parameters to build improved image



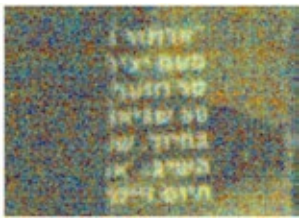
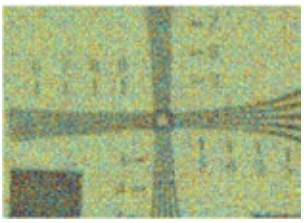
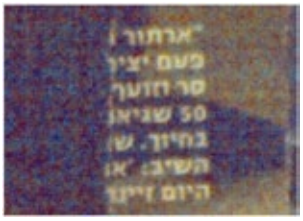
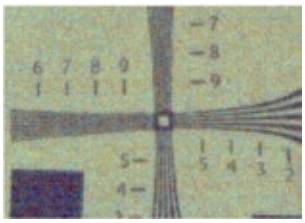
Spectral Sensing: Use a tunable color filter to capture certain spectral slots of the scene

SIS is able to replace every compact imaging camera while providing the following benefits:

- 2 – 4 times more effective pixels
- Improved colors
- Image stabilization
- High dynamic range
- Option to capture also NIR for better low light performance
- Improved SNR
- Lower cost and simplified

In sum: Better Image Quality, Better UX

SIS Demo System

	Resolution	Noise Reduction	Low Light (10LUX)
Conventional			
SIS			

Second Panel

SECOND PANEL

"INSTITUTIONAL INVESTORS' VIEWS ON THE FINANCING OF INNOVATION"

Large institutional investors have increasingly turned their back on venture capital as an asset class. This does not necessarily mean they lack an interest in technology and the financing of innovation. Rather, some leading institutional investors have developed new approaches to the financing of innovation that they will share with the PPF.

Moderator:

Ms. Luba Nikulina
Global Head of Manager Research
Towers Watson (London, UK)

Panelists:

Ms. Michele Cucullu
Director, Private Equity
University of California (USA)

Mr. David Goerz
Executive Vice President, Investment Strategy and Risk Management
Alberta Investment Management Corporation (Canada)

Ms. Nicole Musicco
Vice President, Funds & Co-Investments
Teachers' Private Capital (Canada)

Panel's background information:

Moderator

Ms. Luba Nikulina
Global Head of Manager Research
Towers Watson (London, UK)

Luba Nikulina is Global Head of Manager Research at Towers Watson.

She has over 18 years' industry experience and worked as an investment manager in a major investment firm in Russia prior to joining Towers Watson in 2005. She has worked in Towers Watson's offices in London and New York and played an important role in driving forward Towers Watson's private markets research, leveraging her 'hands-on' experience and taking full advantage of her extensive industry contacts. Prior to taking the leadership of the broader manager research team in 2014, Luba was Global Head of Private Markets at Towers Watson.

Luba works with some of the largest asset owners globally and advises them on developing their private markets governance structures, strategy, portfolio construction and investment selection. Luba is well known in the industry, regularly speaks at conferences and writes research papers in the specialist press.

Luba attended the Advanced Management Program at Harvard Business School and holds an MBA degree from London Business School, MS in Finance from the Finance Academy in Russia and a BA in Linguistics from the Linguistic University in Belarus.

Panelist

Ms. Michele Cucullu
Director, Private Equity
University of California (USA)

Michele Cucullu joined the University of California Regents in February 2007.

Ms. Cucullu has over 14 years of investment experience. Previously, she worked at the California Institute of Technology Endowment and the Exeter Group.

Michele earned a Master of Science degree from the California Institute of Technology and a Bachelor of Science degree from the University of New Orleans.

Panelists

Mr. David Goerz
Executive Vice President, Investment Strategy and
Risk Management
Alberta Investment Management Corporation (Canada)

David Goerz joined Alberta Investment Management Corporation with pension, endowment and sovereign wealth assets under management exceeding $76 billion for 27 clients as EVP, Investment Strategy & Risk Management in March 2013. He is responsible for leading AIMCo's Investment Strategy, Economics, Asset Allocation, and Risk Management disciplines, including directing global tactical asset allocation. Mr. Goerz chairs AIMCo's Management Investment Committee and Tactical Risk Allocation Committee, as well as heading portfolio managment of our Venture Capital investments. He is also a member of the Executive Committee.

Mr. Goerz has more than 23 years of global investment management experience in various leadership and portfolio management roles. Previously, he was Chief Investment Officer of HighMark Capital Management, mPower Advisors, and Morningstar Associates. He has also held positions as Director of Global Asset Allocation Research and Portfolio Manager for Wellington Management Company, as well as portfolio manager and senior investment research positions with TSA Capital Management and ARCO Investment Management. Mr. Goerz serves on the Board of Directors for Axioma, Inc., a quantitative investment and risk management software company, and Mismi, Inc., as well as the Strategic Advisory Board of the CFA Society of San Francisco. He has regularly appeared on CNBC, Fox Business News, as well as Bloomberg TV and Radio focusing on global macroeconomic trends, capital markets, and investment strategy. He is quoted frequently in various investment periodicals.

Mr. Goerz received his BS from UCLA in Applied Mathematics and a MS in Operations Research Engineering from Stanford University.

Ms. Nicole Musicco
Vice President, Funds & Co-Investments
Teachers' Private Capital (Canada)

Nicole Musicco leads the global fund program overseeing all of Teachers' Private Capital's externally managed private equity and venture capital fund positions, and emerging markets co-investment and co-underwriting activities. Since joining Teachers' in 2002, Nicole has held positions of increasing responsibility in both the Direct and Fund investment teams.

Nicole graduated from the HBA and MBA programs at the Richard Ivey School of Business, and from the Bachelor of Science Kinesiology program at the University of Western Ontario.

LONG HORIZON INVESTING IN A SHORT-TERM WORLD

OCTOBER 22, 2014

David Goerz
EVP, Investment Strategy & Risk Management

AIMCo Alberta Investment Management Corporation

GREAT INFLECTION POINTS: WHAT SHOULD INVESTORS DO?

- **Increasingly *Playing in a Crowded Sandbox:*** Chasing less compelling valuations as Alternative allocations increased, straining investment capacity
  - Global Alternative Asset Allocations increased significantly between 2004 – 2012, now representing up to 25-30% of institutional portfolios in US, Canada, Australia
  - Allocations to private investments provide increased diversification and higher potential return, realizing small-company and illiquidity premiums, but challenges are greater now
  - Yet, erosion of illiquidity premium in unlisted assets requires greater reliance on active management and reducing cost, so reliable sources of excess return more valuable
- **Innovation is accelerating by leveraging technology, but allocation of financing capital for private opportunities remains inefficient**
  - Direct private investing is ripe for those that are: nimble, flexible, disciplined, creative, long-term oriented, well-resourced, and well-connected
  - Asset Owners enjoy distinct advantages in sourcing compelling direct investment opportunities others cannot exploit easily or at much greater cost
  - Future Themes research helps direct our focus on favorable market tailwinds
- **Companies need patient long-term capital to build businesses, commercialize innovative ideas and unusual opportunities**
  - Asset owners are distinctly well positioned to play unique role in the real economy

"CANADIAN MODEL" SUCCESS

- **Success Built on Investment Innovation, Doing Uncomfortable Things**
  - What was new in the 1990s is now conventional, but capacity has lagged demand
  - Private allocations provided excess return with compelling diversification
  - Infrastructure, Timberland, Commodities, and Private Equity was underexploited
  - Benefits of past innovation eroding – overwhelming demand undermined illiquidity premium, so chase has gotten harder, yet still opportunities "between-the-cracks"
- **Economies of Scale Improves Access vs. Capacity Constraints**
  - Large sophisticated asset owners can tap into market inefficiencies others can't, while Canadian "asset owners" reputation attracts unique private opportunities
  - Focus on reducing total cost from insourcing investment management and direct deal sourcing to reducing external management expense
  - Scale affords institutionally competitive staffing and affords skills needed for overall complexity – Ability to attract, retain, and nurture top talent increases with AUM
  - Unlisted, capacity constrained assets difficult to rebalance, accommodate cash flow
  - Outsourcing through Funds should have been cost effective, but expenses still high, capacity remains limited, and co-investing can be disappointing due to adverse selection, thus realizing size and illiquidity risk premium objectives still allusive

NEW DAWN AWAKENING ASSET OWNERS
THE RISE OF LONG-TERM INVESTORS

- **Investment Capital Is Growing Rapidly, Straining Investment Capacity**
  - With scale, many now operating on commercial basis with longer horizons resulting in better alignment for exploiting unlisted inefficiencies, lower direct costs
  - Push into higher private alternative allocations could stall due to reduced illiquidity premium (stretched valuations, deal competition) and high management costs
  - Resistance to build institutionally competitive teams has severe adverse and unintended consequences; No room or patience for non-economic agendas
- **Longer Horizon Expands Opportunities, Increases Potential Return**
  - Yet, Too Many *Playing Not to Loose – Doing No Wrong* is not *Doing Right*
  - Natural long-term investors need courage to defy short-term behavioral bias and not be limited by uneconomic misguided constraints reducing flexibility
  - Short-termism, exaggerated risk aversion, new regulations, artificial constraints, and other behavioral biases are significant hurdles impeding exceeding objectives
  - Greater passion needed for growing great companies, building projects, exploring unconventional opportunities, all with a focus on a longer time horizon
  - Fear of direct/active investing raises cost of capital and lowers return potential; Market inefficiencies inversely correlated with investment quality

CANADIAN PENSION MODEL
NEXT LONG HORIZON EVOLUTION

- **Extraordinary Results Not Possible by Ordinary Means**
  - Anticipate new investment opportunities and remain disciplined – If a strategy appears comfortable, time to stretch and explore new horizons
  - Adopt a well-defined, intuitive investment philosophy driving strategy disciplines
  - New approach to sourcing direct investment and co-investment opportunities
  - Promote a better understanding of good vs. bad "Leverage" and "Risk"
  - Embrace active management and direct investing – Don't dismiss *efficient liquid strategies* and *Global TAA* to lever active return potential without leveraging risk
  - When capacity becomes strained, new *Alpha Engines* must be developed
- **Underexploited Edge for Asset Owners Pursuing Innovative Ideas**
  - Substantial advantage in long horizon investing underutilized because it is difficult
  - Still many opportunities overlooked "between-the-cracks" of traditional investments
  - Opportunities created by financial regulation, inefficiencies, distress, lack of creativity
  - Efficient access to long-term capital needed to accelerate and exploit Innovation, thus better/more efficient and flexible capital financing structures must be developed
  - Explore and understand impact of *Secular and Future Themes* – even if a guide

EASIER TO DO THE COMFORTABLE THING

What is the difference between a bleak and a bright future?

- Rapid innovation has fundamentally lifted our living standards
- Its persistence lies in entrepreneurship and free market incentives
- Potential economic growth of 2-3% is normal – return to risk capital rewarded incentivizing research, development, innovation
- Asset owners are well positioned to play a distinctly unique role providing adaptive long-term capital at critical stages
- Just because its hard doesn't mean we shouldn't try – somebody else's *New Normal* doesn't have to be our destiny

Investment Opportunity

The future may be better than you think – wide range of opportunities to be exploited

- Longer horizon increases opportunities between-the-cracks and potential return
- Need courage to defy short-term behavioral bias and not limit flexibility
- Need to "re-discover" pioneering spirit of active and direct investing

Third Panel

THIRD PANEL

"THE TAIWANESE MODEL TO LINK RESEARCH INSTITUTIONS, LARGE CORPORATIONS, FINANCING INSTRUMENTS TO CREATE NEW STARTUPS"

Taiwan has been particularly successful in linking research institutions, large corporations and financing instruments to create new startups, notably in semiconductors, microelectronics and hardware. Since 1979, the Industrial Technology Investment Corporation (ITIC) has played a critical role in building this ecosystem. Herb Lin, CEO of ITIC, will identify and discuss the specific success factors of the Taiwanese model.

He will be interviewed by Franceska Banga, CEO of the New Zealand Venture Investment Fund (NZVIF). The NZVIF and Taiwan's National Development Fund have recently launched a US$ 160 million cross-border venture capital fund.

Panelist: **Mr. Herb Lin**
President
Industrial Technology Investment Corporation – ITIC
(Taiwan)

Interviewer: **Ms. Franceska Banga**
CEO
New Zealand Venture Fund (NZ)

Panel's background information:

Panelist

Mr. Herb Lin
President
Industrial Technology Investment Corporation – ITIC (Taiwan)

Mr. Herb Lin has been the President of GVT Fund, L.P. at Industrial Technology Investment Corporation since April 2008 and is its Managing Partner.

Mr. Lin has extensive experience in venture capital and in high-tech industry. From March 2007 to April 2008, Mr. Lin served as a Senior Vice President of WK Technology, where he defined investment strategies, raised funds from overseas investors, sourced investment targets in Taiwan and China, performed analysis and due diligence, developed investment structures, negotiated investment contracts, worked with portfolio companies at board level, and managed equity disposition. From October 2003 to October 2006, Mr. Lin served as a Senior Vice President of AsiaVest Partners, TCW/YFY Ltd. From February 2003 to April 2008, he served as a Senior Vice President at Crimson Capital Holdings and headed the Taipei team responsible for the fund's Asian portfolio. From July 1981 to February 1993, he worked for Intel Corp. as a Senior Manager for over 12 years at its U.S.A. headquarters, China office and Taipei office. With responsibilities in design and application engineering, working on processor design, and validation as well as manufacturing yield issues. Mr. Lin later headed the product and technical marketing team for the Asia-Pacific region, defining regional marketing strategies, identifying partners for technology transfers, and analyzing market and product trends. In 2000, He joined Intel Capital in China, where he defined investment strategies in China and Taiwan, identified companies with needed technologies or synergies with Intel as investment targets, developed deal structures, negotiated investment contracts, worked with portfolio companies at board level, and managed equity dispositions. Mr. Lin has a Ph.D. in Electrical Engineering from the Santa Clara University.

He holds an M.S. degree in Electrical Engineering from the University of Missouri and graduated in Bio-industrial Mechatronic Engineering from National Taiwan University.

Interviewer

Ms. Franceska Banga
CEO
New Zealand Venture Fund (NZ)

Franceska is the CEO of the $300 million New Zealand Venture Investment Fund which is a government-owned 'fund of funds' started in 2001 and designed to stimulate and secure investment capital for innovative technology companies with high growth potential. Franceska has led NZVIF since its inception, overseeing partnerships with 10 venture capital funds, 15 angel investment networks, and direct and indirect investments into over 180 companies. Franceska is also a director of Auckland Tourism, Events and Economic Development, and the Fred Hollows Foundation New Zealand. With an honours degree in economics and finance, she previously worked for the Ministry of Research, Science and Technology, the New Zealand Treasury, and the Reserve Bank of New Zealand. In 2013, she was the first recipient of the NZ Venture Capital Association's industry leadership award.

Industrial Technology Research Institute (ITRI)

The Industrial Technology Research Institute (ITRI) is a nonprofit R&D organization engaged in applied research and technical services. Founded in 1973, ITRI has played a vital role in transforming Taiwan's economy from a labor-intensive industry to a high-tech industry. Numerous well-known, high-tech companies in Taiwan, such as leaders in the semiconductor industry TSMC and UMC, can trace their origins to ITRI.

Innovative Research

ITRI focuses on six research fields including Information and Communications, Electronics and Optoelectronics, Material, Chemical and Nanotechnology, Medical Device and Biomedical, Mechanical and Systems, Green Energy and Environment. ITRI has aggressively researched and developed countless next-generation technologies. In addition, ITRI's Flexible Electronics Pilot Lab and Nanotechnology Lab provide international-level research platforms where R&D can be conducted jointly with partners. ITRI has also seen significant growth in its intellectual property and new ventures in recent years and is devoted to creating a model that will make Taiwanese manufacturing even more competitive in the international arena.

ITRI Main Buildings

Industrial Technology Investment Corporation (ITIC)

Founded in 1979, Industrial Technology Investment Corporation (ITIC) is a wholly owned subsidiary of Industrial Technology Research Institute (ITRI), the largest and most prestigious industrial research consortium, with more than 6,000 employees, in Taiwan. Since its founding, ITRI has been substantially impacting the technology industry, from semiconductor to computer, communication, material, etc., in Taiwan.

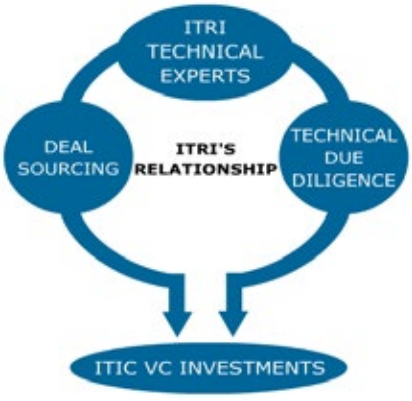
ITIC has Close Relationship with ITRI

ITRI benefits ITIC in both technical due-diligence and deal sourcing. In return, ITIC has been responsible for creating opportunities of technology commercializing for ITRI's laboratories while concurrently generating exceptional returns for ITRI. With the breadth and depth of its research capabilities, ITRI's world-class research institution has supported ITIC's venture capital practice, collectively driving and transforming Taiwan's high technology movement.

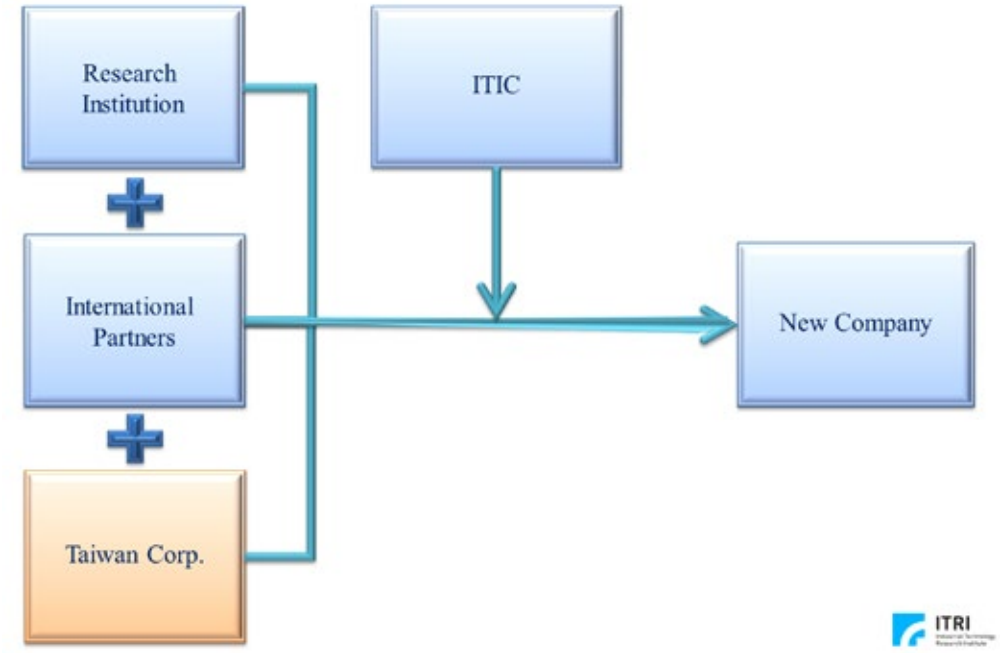
ITIC has a unique resource from ITRI in both deal sourcing and technical due-diligence.

One of the important roles ITRI plays is providing assistance on technical due diligence. Due to ITRI's abundant research professionals, ITIC is able to utilize this resource and invest in seed to early-stage companies. ITIC's team is constantly interacting with respective senior managers from ITRI, sharing detailed technical issues, which ultimately results in a more knowledgeable and experienced team in terms of technical due-diligence capabilities.

As the VC arm of ITRI, ITIC enjoys a great amount of deal flow from this relationship. An example of this deal flow source is Taiwan Mask Corp. (TMC). Founded in 1988, TMC is an early venture investment of ITIC where ITIC facilitated its spin-off from ITRI. TMC went public in 1995 and is currently the largest provider of mask service in Asia except Japan. Another deal flow source ITIC enjoys is through the process of technology transfer.



Model 1.0

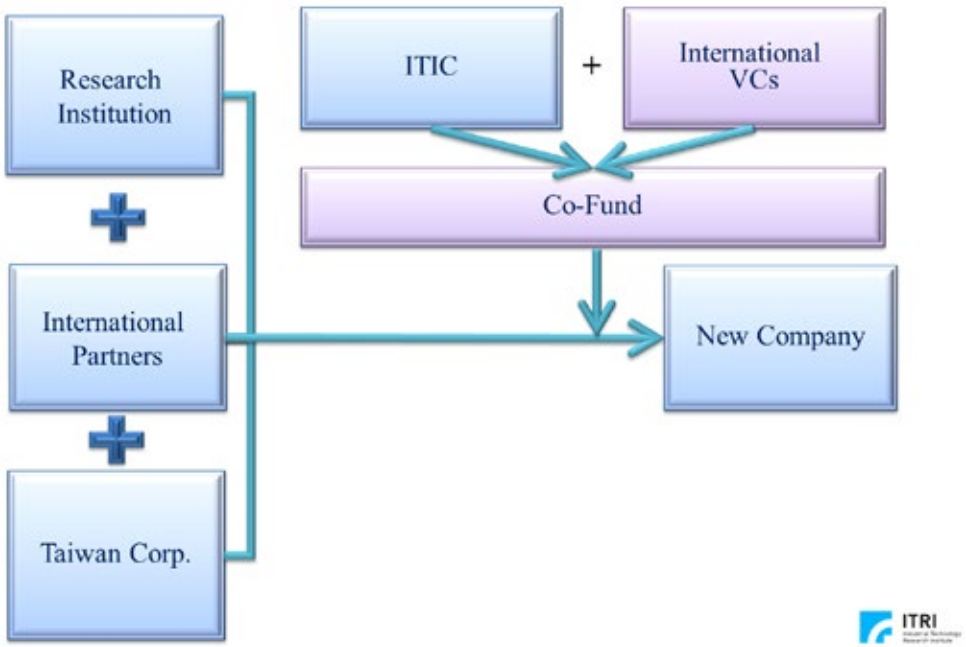


Discerning the industry trend, ITIC has been able to catch the critical industries for its investment focus over time. ITIC initiated its investment in the semiconductor industry. Since early 1980s, ITIC has actively invested in the semiconductor industry. United Microelectronics Corp. founded in 1980, ITIC's first investment entity, has become the second largest IC foundry in the world.

ITIC is one of the first investment firms in Taiwan to have venture capital services. Well before the term “Venture Capital” was conceptualized in Taiwan, ITIC already had its first successful investment in 1980 with United Microelectronics Corp. (UMC). ITIC facilitated UMC to be spun off from ITRI and became one of UMC’s founding partners.

Since its inception, ITIC has been instrumental in leading Taiwan's initial ventures into technology-based businesses, such as integrated circuits, automation, opto-electronic display, etc. ITIC is an original shareholder of some industry leaders such as UMC, Taiwan Mask Corp., Acer Display Technologies, Inc.(renamed as AU Optronics Corp.).

Model 2.0



ITIC helped local manufacturers of laser machines used to repair electronics such as LCD panels or drill into metal are expected to receive a boost with Taiwan-Japan venture to bring in Japan's top laser machine maker to two Taiwanese electronics firms releases its first product to set up Cyber Laser Taiwan Inc.

Historically, ITIC has focused on investing through in-house capital. However, in recent years, ITIC has been extending its investment business to venture capital fund operations. ITIC's investment domain has also expanded into foreign areas, primarily in the US. Today ITIC participates in funding more than 50 companies, and operates an incubation center with around 30 start-ups in various high technology industries. ITIC is one of the leaders in Taiwan's venture capital business.

ITIC does not only review submitted investment deals, but also originates and initiates venture projects internally, leveraging great resources from ITRI. In addition, ITIC is dedicated to coaching entrepreneurs and management team of ITIC's portfolio companies and potential investment deals. We view each new investment as a long-term partnership based upon mutual respect, common goals and a joint commitment to realizing the rewards of building a successful business.

Open Lab

Since operations began in 1996, we have served a total of 342 companies, of which more than 9,316 people have been ITRI residents through the Open Lab/Incubator project. At present, we have 70 tenant companies with 1,006 people as part of the ITRI Open Lab project. ITRI has assisted and fostered the establishment and development of more than 185 startups, with an accumulated paid-in capital of more than NT$63.4 billion.

Of these new enterprises, 48 entered the Hsinchu Science Park in Taiwan after graduation and 18 filed for an IPO. We own abundant R&D as well as venture capital resources, which can support the development of telecommunications technology, electro-optical technology, precision machinery, IC design, chemical materials, medical instrumentation, green energy, and biotechnology. The above capabilities are closely linked to ITRI's R&D centers and laboratories for maximum synergy.

Outstanding Performance

- High occupancy rate: From 79 (2009) to 98 percent (2013) and remained higher than 90% for 3 years (2011-2013).
- Accumulated invested capital of incubated firms: US$2.14 billion.
- Accumulated number of jobs created: 19,100.
- IPO rate of incubates : 10%.
- Number of incubation graduates that gained approval to set up at the Science Park: 48.
- Fundraising: Over US$37.8 million for ITRI incubated companies and US$13.88 million for ITRI-incubation Network.
- Excellent acquired investment: Qualcomm also bought Pixtronix Co. for US$170 million and anti-virus company Kaspersky-Titan invested US$1 million in Arc Corp.

Incubator

The Incubation Center of Industrial Technology Research Institute (ITRI) is the first incubator founded in Taiwan. Since its establishment in 1996, the center has taken on the mission of offering assistance to high-technology start-ups. In August 2013, the ITRI Incubator obtained certifications from the NBIA softlanding and from EBN BIC. In October 2013, Taiwan's GreTai Securities Market, an over-the-counter trading mechanism for emerging stocks, certified the ITRI Incubator as the only incubation center qualified to help technology firms with IPO processing.

Fostering Entrepreneurship and CEO Leadership

ITRI employs around 6,000 personnel, including over 1,300 who hold Ph.D.s and 3,000 with master's degrees. By disseminating both technology and talent, ITRI has led the technology industry into the 21st century and has cultivated over 140 CEOs in the local high-tech industry. In addition to its headquarters in Taiwan, ITRI has branch offices in the California Silicon Valley, Tokyo, Berlin, Moscow and Eindhoven.

ITRI, headquartered in Taiwan, has offices in the United States, Japan, Germany, Russia and Netherlands in an effort to extend its R&D scope and promote opportunities for international cooperation. In the United States, it has long-term collaborative arrangements with MIT, Carnegie Mellon University, the University of California at Berkeley and Stanford University.

Group shooting for ITRI receives 2014 R&D 100 awards.

To date, ITRI holds more than 20,000 patents and has assisted in the creation of more than 240 start-ups and spin-offs. In 2013, ITRI recieved three R&D 100 Awards: iAT Technology, FluxMerge and ButyFix. In 2012, ITRI recieved six R&D 100 Awards: Lignoxy, TEMM, SideLighter, aePLASMA, Light&Light and AVA-Clamp. In 2011, ITRI received six prestigious international awards: The Excellent Organization, Solar Industry Awards in the U.K. for Solar Radome, two R&D 100 Awards, two Wall Street Journal Technology Innovation Awards, and the Silver Award for The Society in Information Display's (SID) Display of the Year Awards. In 2010, the institute received five prestigious international awards: The Overall Gold Wall Street Journal Technology Innovation Award for its FlexUPD technology, runner-up in the Semiconductor category for its MDPS (Micro-Deformable Piezoresistive Sensor Technology) and three R&D 100 Awards for FlexUPD, i2/3DW and Reddex. In 2009, the institute also received four prestigious international awards: The Wall Street Journal's 2009 Technology Innovation Award for its FleXpeaker technology, an R&D 100 Award for the High Safety STOBA Lithium Battery Material Technology, the iF Design Award from the International Forum Design in Germany for ITRI's Fluid Driven Lighting System, and the Red Dot Design Award by the Design Zentrum Nordrhein Westfalen in Essen, Germany, for its Flexio Radio Technology.

NATIONAL DEVELOPMENT FUND OF TAIWAN / NEW ZEALAND VENTURE INVESTMENT FUND CO-FUND ARRANGEMENT

Background

Taiwan's National Development Fund – Executive Yuan (NDF) and the New Zealand Venture Investment Fund Limited (NZVIF) have entered into a Co-Fund arrangement to jointly invest into Venture Capital (VC) Funds that are making investments in Taiwan and New Zealand.

Up to USD160 million will be made available for investment by the Co-Fund over five years.

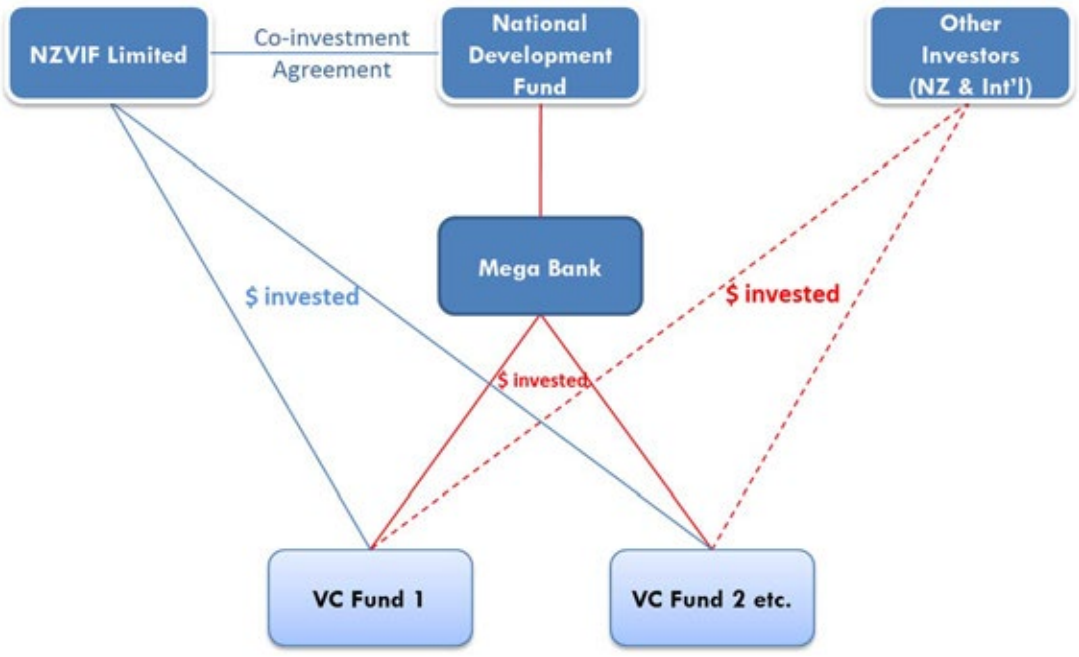
The establishment of the Co-Investment agreement has been in progress since late 2010 and was signed by way of a Letter of Agreement in October 2012.

The purpose of the Co-Fund is to facilitate VC investment into high growth companies from New Zealand and Taiwan as well as to promote regional economic cooperation through the vehicle of investment.

Other objectives include:

- The sharing of market information of venture investments in New Zealand and Taiwan;
- Promoting exchanges of experience between these two organisations;
- Developing a partnership structure that can be replicated by NZVIF to encourage further Co-Investment Funds with other sovereign funds.

Structure



Key Guidelines

NDF and NZVIF are able to invest, on an equal basis, up to a maximum of USD20 million for each venture capital fund (USD40 million in total).

The combined investment of the Co-Fund may not exceed 60% of the total venture capital fund size. Private sector investment of at least 40% of the total fund size must be raised in addition to the Co-Fund investment.

Portfolio investments must be made into both New Zealand and Taiwanese companies equally, that is 50% of investments must be in New Zealand companies and 50% in Taiwanese companies.

Taiwanese companies are:

- Companies that are Incorporated in Taiwan, or
- have established or intend to establish a subsidiary in Taiwan, or
- conducts substantial business activity in Taiwan.

The definition of New Zealand companies is:

- Companies that have the majority of assets and employees in New Zealand at the time an initial investment is made.

A company that is originated in New Zealand and migrates to Taiwan can be considered as both a New Zealand and a Taiwanese company. A minimum of 10% must be invested in Taiwanese incorporated companies.

A Fund will ensure that it has sufficient resources to execute on an investment strategy that is consistent with the objectives of the Co-Fund. This is likely to require a presence or relationships in one or both countries.

A Fund must not invest in any company primarily involved in property development, retailing, mining, banking or the hospitality industry.

Progress to Date

The Co-Fund has had strong interest from a number of New Zealand and Taiwan-based Fund Managers in raising capital via the Co-Fund. 2013 saw a delegation from Taiwan consisting of 14 individuals from six Venture Capital funds spend a week in New Zealand assessing opportunities.

In August 2014, GRC Sinogreen Fund II achieved its first close of USD75 million including a USD40 million commitment from the NDF/NZVIF Co-Fund. GRC Managers is an international venture capital fund manager run by a team of experienced venture capitalists with offices in Beijing, Taipei and Auckland.

Participants

List

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SAVE THE DATE: OCTOBER 21-24, 2015

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General Information

Bpifrance Le Lab is a think tank dedicated to French SMEs and Midcaps.

Its mission is to improve the knowledge of French SMEs by bringing together those who make the company and those who study it (entrepreneurs and researchers). They complete Bpifrance's mission: "One finances best what one knows best".

Its aim is to bridge the gap between entrepreneurs and scholars in order for everyone to confront different points of view, deepen the reflections and open new debates. Moreover, it aims at a better knowledge of companies, in order to offer them more adequate answers to their needs.

This think tank supports research, no matter which one, by opening its data to all SMEs data producers and analysts- through calls to projects.

How does Bpifrance Le Lab work and how are the subjects chosen?

Bpifrance has gathered all sorts of data on SMEs, never exposed before. These resources are now available to the scientific community selected through a call to projects by Bpifrance Le Lab.

These call to projects aim at bringing forward original and exclusive works that offer a new perspective on SMEs and feed discussions and sharing of ideas at the heart of Bpifrance Le Lab.

43 projects were proposed, very different from each other, whether by the typology of the candidates (different French Universities) or the subjects submitted (key factors of success for innovation support schemes, relationship between intangible assets and Midcaps growth, comparative study France/Scandinavian country on the efficiency of public support for the internationalization of companies). 8 projects have been selected by an independent panel from Bpifrance Le Lab, made of 7 personalities from the entrepreneurship, scholars' worlds and institutions.

One study already published: "Do Entrepreneurs know how to anticipate their activity?"

In this study, 10 years of business surveys realized with 24000 SMEs were used.

Organization:

Bpifrance Le Lab does not have a specific legal structure, nor does it have outside investors, board of directors or scientific advisors.

It is based on:

- The Bpifrance teams of the Direction of Evaluation, Studies and Prospective (DEEP)
- An advisory board made of 19 qualified personalities coming from outside of Bpifrance with various backgrounds, experiences and know-hows. It is composed of scholars and entrepreneurs, teachers / researchers in management, macro and micro economy, sociologists, historians, town planners…

What's the use of Bpifrance Le Lab for Bpifrance and beyond?

To encourage the research on SMEs and transcribe it in a way that it is spread in the world of enterprise, to break preconceived ideas, to develop exchanges (between schools, universities and entrepreneurs)… around 3 lines of action:

- Access to data
- Promotion of research (short cycles, computer graphics, dedicated web site: bpifrance-lelab.fr)
- Discussion (working groups, conferences for entrepreneurs, researchers, and others)

BDC CAPITAL

Canada

Financing innovation in Canada

BDC Capital is focused on contributing to the success of Canada's most innovative, growth-oriented companies from various sectors and at all stages of the company lifecycle. These companies contribute significantly to the domestic economy and require a full spectrum of risk capital solutions.

Our **Growth & Transition Capital** team offers a range of risk capital solutions from cash flow loans, to mezzanine financing, to quasi-equity and equity.

Our **Venture Capital** team is Canada's largest and most active institutional player in the VC market.

Here are some of the ways BDC Capital is helping finance Canadian innovation:

$1.6B BDC Capital manages **$1.6B** in current and planned investments.

3 We have **three internal venture funds** that are fully aligned with the private sector and investing in the areas of IT, healthcare and industrial, clean and energy technology.

39 Our **Fund of Funds** team manages investments in **39 of Canada's top funds**. They invest as a private market-driven institutional LP, alongside other institutions and individuals, to support high-performing GPs managing larger funds (typically, $100M or more).

87 Our **Strategic Investments and Partnerships** team leads BDC Capital's activities in the area of emerging models in the VC ecosystem through direct and indirect investments. This team has invested in **87 early stage companies** via eight accelerators nationwide.

They are also collaborating with three university commercialization models:
TandemLaunch Technologies of Montreal | Creative Destruction Lab of Toronto | Accel-Rx in Vancouver

$400M In addition, BDC Capital manages the Government of Canada's involvement in the **$400M Venture Capital Action Plan**.

Did you know?

BDC Capital currently participates in more than **15%** of Canadian venture deals annually and, through our indirect investing, supports close to **70%** of all VC funds in Canada.

Find out more at bdccapital.ca or follow us on Twitter @BDC_Capital.