RESEARCH, INNOVATION, ENTREPRENEURSHIP: THE NECESSARY CHAIN FOR SUSTAINED ECONOMIC GROWTH

Alberto Sangiovanni-Vincentelli

Start-ups (about 7 co-founded):
  - Co-Founder, Member of the Board, Cadence Design Systems
  - Co-founder Synopsys

Industry (strategy, organization and technology consulting):
  - Science and Technology Advisory Board, General Motors
  - Technology Advisory Council, United Technologies....

Private Equity and VC
  - President, Strategy Committee, Italian Strategic Fund (8 Billion)
  - Advisory Board (Walden International, Sofinnova, Innogest, Xseed)
  - Investment Committee (Fondo Atlante, Fondo Next)
Or... A View from a Researcher to a Casual Entrepreneur

• Innovation in Action
• The Economic Engine and Research
• Some Disruptive Research
Innovation

• Innovation is not an option: «every job created in centers of excellence in innovation generates at least five other jobs in other domains (services, traditional industry, entertainment) and these jobs are paid way better than in other places» (E. Moretti, Berkeley)

• There is not a single way of innovating
go not confuse invention with innovation

• Leveraging research for innovation in:
  • Established companies
  • Start-ups
### Twelve potentially economically disruptive technologies

<table>
<thead>
<tr>
<th>Mobile Internet</th>
<th>Increasingly inexpensive and capable mobile computing devices and Internet connectivity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Automation of knowledge work</td>
<td>Intelligent software systems that can perform knowledge work tasks involving unstructured commands and subtle judgments</td>
</tr>
<tr>
<td>The Internet of Things</td>
<td>Networks of low-cost sensors and actuators for data collection, monitoring, decision making, and process optimization</td>
</tr>
<tr>
<td>Cloud technology</td>
<td>Use of computer hardware and software resources delivered over a network or the Internet, often as a service</td>
</tr>
<tr>
<td>Advanced robotics</td>
<td>Increasingly capable robots with enhanced sensors, dexterity, and intelligence used to automate tasks or augment humans</td>
</tr>
<tr>
<td>Autonomous and near-autonomous vehicles</td>
<td>Vehicles that can navigate and operate with reduced or no human intervention</td>
</tr>
<tr>
<td>Next-generation genomics</td>
<td>Fast, low-cost gene sequencing, advanced big data analytics, and synthetic biology (&quot;writing&quot; DNA)</td>
</tr>
<tr>
<td>Energy storage</td>
<td>Devices or systems that store energy for later use, including batteries</td>
</tr>
<tr>
<td>3D printing</td>
<td>Additive manufacturing techniques to create objects by printing layers of material based on digital models</td>
</tr>
<tr>
<td>Advanced materials</td>
<td>Materials designed to have superior characteristics (e.g., strength, weight, conductivity) or functionality</td>
</tr>
<tr>
<td>Advanced oil and gas exploration and recovery</td>
<td>Exploration and recovery techniques that make extraction of unconventional oil and gas economical</td>
</tr>
<tr>
<td>Renewable energy</td>
<td>Generation of electricity from renewable sources with reduced harmful climate impact</td>
</tr>
</tbody>
</table>
## Economic Potential

<table>
<thead>
<tr>
<th>Category</th>
<th>Details</th>
<th>Numbers</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>The Internet of Things</strong></td>
<td>300% increase in connected machine-to-machine devices over past 5 years</td>
<td>1 trillion Things that could be connected to the Internet across industries such as manufacturing, health care, and mining</td>
</tr>
<tr>
<td></td>
<td>80–90% Price decline in MEMS (microelectromechanical systems) sensors in past 5 years</td>
<td>$36 trillion Operating costs of key affected industries (manufacturing, health care, and mining)</td>
</tr>
<tr>
<td><strong>Cloud technology</strong></td>
<td>18 months Time to double server performance per dollar</td>
<td>2 billion Global users of cloud-based email services like Gmail, Yahoo, and Hotmail</td>
</tr>
<tr>
<td></td>
<td>3x Monthly cost of owning a server vs. renting in the cloud</td>
<td>$1.7 trillion GDP related to the Internet</td>
</tr>
<tr>
<td><strong>Advanced robotics</strong></td>
<td>75–85% Lower price for Baxter than a typical industrial robot</td>
<td>320 million Manufacturing workers, 12% of global workforce</td>
</tr>
<tr>
<td></td>
<td>170% Growth in sales of industrial robots, 2009–11</td>
<td>$6 trillion Manufacturing worker employment costs, 19% of global employment costs</td>
</tr>
<tr>
<td><strong>Autonomous and near-autonomous vehicles</strong></td>
<td>7 Miles driven by top-performing driverless car in 2004 DARPA Grand Challenge</td>
<td>1 billion Cars and trucks globally</td>
</tr>
<tr>
<td></td>
<td>1,540 Miles cumulatively driven by cars competing in 2005 Grand Challenge</td>
<td>450,000 Civilian, military, and general aviation aircraft in the world</td>
</tr>
<tr>
<td></td>
<td>300,000+ Miles driven by Google’s autonomous cars with only 1 accident (which was human-caused)</td>
<td>$4 trillion Automobile industry revenue</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$155 billion Revenue from sales of civilian, military, and general aviation aircraft</td>
</tr>
</tbody>
</table>
Gartner Hype Cycle 2014

Peak of Inflated Expectations

Internet of Things

http://www.gartner.com/technology/research/hype-cycles/
Google's robotic cars have about $150,000 in equipment including a $70,000 LIDAR (laser radar) system. The range finder mounted on the top is a Velodyne 64-beam laser. This laser allows the vehicle to generate a detailed 3D map of its environment. The car then takes these generated maps and combines them with high-resolution maps of the world, producing different types of data models that allow it to drive itself.
Google and Facebook

Google acquired Titan Aerospace, the drone startup that makes high-flying robots which was previously scoped by Facebook as a potential acquisition target, the WSJ reports. The deal comes after Facebook disclosed purchase of U.K.-based Ascenta for its globe-spanning Internet plans. Both Ascenta and Titan Aerospace are in the business of high altitude drones integral to blanketing the globe in cheap, omnipresent Internet connectivity to help bring remote areas online.

That’s not all the Titan drones can help Google with, however. The company’s robots also take high-quality images in real-time that could help with Maps initiatives, as well as contribute to things like “disaster relief” and addressing “deforestation,”....
This week, years after that first sighting, Tesla announced plans for what it calls the “Gigafactory,” a 10-million-square-foot plant for making car batteries. …But it’s not just the prospect of a gasoline-free future that has sparked such excitement about the Gigafactory. The same basic lithium-ion tech that fuels Tesla’s cars also runs most of today’s other mobile gadgets, large and small. If Tesla really produces batteries at the scale it’s promising, cars could become just one part of what the company does. **One day, Tesla could be a company that powers just about everything, from the phone in your pocket to the electrical grid itself.**

Earlier this month, as rumors swirled that Apple might want to buy Tesla, *San Francisco Chronicle* reported that Tesla CEO Elon Musk had indeed met with the iPhone maker. **Musk later confirmed** that Tesla and Apple had talked, but he wouldn’t say what about.
Silicon Valley: The land of Innovation
Law of Large Numbers

1,700+ ideas/researchers canvassed
~950 resulting start-up ideas analyzed in detail

18 Companies Funded

16 Live

2 Shut Down
DigitAB
StemCor

Xseed Early Investment VCs

8 companies past seed stage
Liquidity and Returns: Exit Strategies

- Exit options
  - IPO
  - M&A
  - Bankruptcy
    - Chapter 7: basic liquidation; also known as straight bankruptcy;
    - Chapter 11: rehabilitation or reorganization, known as corporate bankruptcy, it typically allows companies to continue to function while they follow debt repayment plans;
  - Dissolution (Shutdown)
- Typical venture portfolio performance:
  - Out of every 10 investments
    - Half do not return capital
    - 1 returns >10X
    - Rest return 1-10X
What Drives Venture Returns?

- Market growth not absolute size
- Efficiency of capital deployment
- Irrational exuberance in exit markets
- A handful of big winners

And most of all

Fundamental Innovation—The (Tech) world isn’t “flat”

Source: M. Borrus, Xseed
Or... A View from a Researcher to a Casual Entrepreneur

- Innovation in Action
- The Economic Engine and Research
- Some Disruptive Research
The (Tech) World Isn’t Flat: Distribution of most referenced patents

Source: ATP and George Mason University

Oregon, Washington (Microsoft, Intel U. Wash, Toronto)

Silicon Valley

LA, S. Diego (Qualcomm, Defense UCLA, UCSD)

Washington

Texas (Houston, TI, Freescale U. Texas)

Michigan (GM, Ford, Chrysler, U. Michigan)

Illinois (Motorola, U. Illinois)

Boston (Medical, HiTech Harvard, MIT)
### Trend in Investment

<table>
<thead>
<tr>
<th>Region</th>
<th>Q2 2011</th>
<th>Q1 2012</th>
<th>Q2 2012</th>
</tr>
</thead>
<tbody>
<tr>
<td>Silicon Valley</td>
<td>$1,000</td>
<td>$1,200</td>
<td>$1,300</td>
</tr>
<tr>
<td>New England</td>
<td>$1,450</td>
<td>$1,600</td>
<td>$1,800</td>
</tr>
<tr>
<td>NY Metro</td>
<td>$2,300</td>
<td>$2,500</td>
<td>$2,700</td>
</tr>
<tr>
<td>LA/Orange County</td>
<td>$3,300</td>
<td>$3,500</td>
<td>$3,700</td>
</tr>
<tr>
<td>San Diego</td>
<td>$4,200</td>
<td>$4,400</td>
<td>$4,600</td>
</tr>
<tr>
<td>Midwest</td>
<td>$5,300</td>
<td>$5,500</td>
<td>$5,700</td>
</tr>
<tr>
<td>Northwest</td>
<td>$6,300</td>
<td>$6,500</td>
<td>$6,700</td>
</tr>
<tr>
<td>DC/Metroplex</td>
<td>$7,300</td>
<td>$7,500</td>
<td>$7,700</td>
</tr>
<tr>
<td>Southeast</td>
<td>$8,300</td>
<td>$8,500</td>
<td>$8,700</td>
</tr>
<tr>
<td>Texas</td>
<td>$9,300</td>
<td>$9,500</td>
<td>$9,700</td>
</tr>
<tr>
<td>Colorado</td>
<td>$10,300</td>
<td>$10,500</td>
<td>$10,700</td>
</tr>
<tr>
<td>SouthWest</td>
<td>$11,300</td>
<td>$11,500</td>
<td>$11,700</td>
</tr>
<tr>
<td>North Central</td>
<td>$12,300</td>
<td>$12,500</td>
<td>$12,700</td>
</tr>
<tr>
<td>Philadelphia Metro</td>
<td>$13,300</td>
<td>$13,500</td>
<td>$13,700</td>
</tr>
<tr>
<td>Upstate NY</td>
<td>$14,300</td>
<td>$14,500</td>
<td>$14,700</td>
</tr>
<tr>
<td>Sacramento/N.Cal</td>
<td>$15,300</td>
<td>$15,500</td>
<td>$15,700</td>
</tr>
<tr>
<td>South Central</td>
<td>$16,300</td>
<td>$16,500</td>
<td>$16,700</td>
</tr>
<tr>
<td>AK/HI/PR</td>
<td>$17,300</td>
<td>$17,500</td>
<td>$17,700</td>
</tr>
<tr>
<td><strong>Grand total</strong></td>
<td>$56,044</td>
<td>$57,044</td>
<td>$58,044</td>
</tr>
</tbody>
</table>
38 venture-backed companies raised $2.9 billion through public offerings in 1Q 2014. Number of deals increased by 90%, while capital raised registered a 17% decrease from the previous quarter.

The largest IPO of the quarter was Castlight Health Inc. (NYSE: CSLT), which completed a $178 million IPO.
119 M&As of venture-backed companies in U.S. garnered $17 billion during 1Q 2014, the highest quarterly figure since 3Q 2000, when $23 billion were raised.

In contrast with 4Q 2013, when a total of 122 transactions accumulated $12 billion, though the number of M&As fell by 2%, the amount raised rose by 37%.

The largest M&A of the quarter was Nest Labs Inc., which was acquired by Google Inc. (Nasdaq: GOOG) for $3.2 billion.
The SCIENCE-Application Dilemma

Raffaello Sanzio, The Athens School
<table>
<thead>
<tr>
<th>Quest for Fundamental Understanding?</th>
<th>Considerations of Use?</th>
</tr>
</thead>
<tbody>
<tr>
<td>NO</td>
<td>YES</td>
</tr>
</tbody>
</table>

- **Pure Basic Research** (Bohr)
- **Use-Inspired Basic Research** (Pasteur)
- **Pure Applied Research** (Edison)

D. Stokes

---

**Pasteur’s Quadrant**
Research Centers-Industry Relationships

• Researchers should be rewarded on the basis of their contributions in all areas, including professional activities
• Reciprocal respect and attention to respective roles
• Beware of patentitis!!! “Speed not patents”
• Beware of paperitis!! More value less numbers
• Transfer of technology as viral infection!!!
  – Visiting professionals and industrial leaves
• Formation of new companies favored
Or... A View from a Researcher to a Casual Entrepreneur

- Innovation in Action
- The Economic Engine and Research
- **Some Disruptive Research**
The Emerging IT Scene!

The Cloud!

Infrastructural core

Sensory swarm

Mobile access

Courtesy: J. Rabaey
Computers and mobiles to disappear!

Predictions: 7 trillions devices servicing 7 billion people!
1,000 devices per person by 2025

The Immersed Human

Real-life interaction between humans and cyberspace, enabled by enriched input and output devices on and in the body and in the surrounding environment

Courtesy: J. Rabaey
Another One: BioCyber (?) Systems
Linking the Cyber and Biological Worlds

Examples: Brain-machine interfaces and body-area networks

Courtesy: J. Rabaey
Towards Integrated Wireless Implanted Interfaces

Moving the state-of-the-art in wireless sensing

[Diagram of a brain labeled with components: encoder, clock, regulator, memory, Tx, ADC, LNA, DSP, electrodes.]

Power budget: mWs to 1 mW

[Illustration art: Subbu Venkatraman]
Vision 2025

- Integrated components will be approaching molecular limits and/or may cover complete walls
- Every object will be smart
- The Ensemble is the Function!
  - Function determined by availability of sensing, actuation, connectivity, computation, storage and energy
  - Collaborating to present unifying experiences or to fulfill common goals

A humongous networked, distributed, adaptive, hierarchical, hybrid control problem
The Problem Space (TerraSwarm)
Nano Materials:
The Fully Biodegradable Plastic
Fully Biodegradable Vegetable Plastics

World production:
260 Millions ton of petrol plastic /year

Biodegradation time > 1000 years

Vegetable waste from food industry:
26 Millions tons/year in Europe only!

Biodegradation time:
a few years in humid environment
Biodegradable Vegetable Plastics
The Magic Sponge
Engineered Sponges

- The Magic Sponge
- Reversible hydrophobic/hydrophilic behavior by nanoparticle functionalization
- Engineered chemical affinity: oleophilic versus hydrophobic behavior
Titanium Dioxide light-induced hydrophilicity

Oleic acid-capped TiO$_2$ nanorods length 20 nm diameter 3 nm

Polymers

UV laser irradiation

Spatial control of wetting properties!
**Synthetic Biology**

συνθέσις *n.* 1.a. the combination of separate elements to form a coherent whole.

- Synthetic biology seeks, through understanding, to design biological systems and their components to address a host of problems that cannot be solved using naturally-occurring entities.
- Enormous potential benefits to medicine, environmental remediation and renewable energy.
Microbial Synthesis of Artemisinin

Off-the-shelf parts?

AcCoA  HMG-CoA  AcAcCoA  Mev  Me  Artemisinin

Courtesy: Jay Keasling
Applications of Synthetic Biology

Energy Crop
- Water saving
- No fertilizer
- Doubled photosynthetic efficiency

Biodiesel and bio-jet fuel
- No compromise
- Fully compatible with existing infrastructure

Natural product drugs
- Capture all of the chemistry in nature
- Construct a microbe that can produce any natural product

Courtesy: Jay Keasling
Final Words of Wisdom
How About Education?
The Way Forward

- Everything is Connected: Society, Electronic and System Industry facing an array of complex problems from design to manufacturing involving complexity, power, reliability, re-configurability, integration, etc.
- Complexity is growing more rapidly than ever seen
- Interactions among subsystems increasingly more difficult to predict
- Pre-existing systems put to work to provide new services
- Need work at all levels: Methodology, Modeling, Tools, Algorithms

- Deep collaboration among
  - Governments, industry, and research centers
  - Different Disciplines: Control, Communication, Computer Science, Electrical Engineering, Mechanical Engineering, Civil Engineering, Chemistry, Biology....