Innovation as a Collective Action Challenge

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Board on Science, Technology, and Economic Policy
The National Academies

Innovation is Seen as Key to Addressing Global Mega-Challenges

- Fostering Economic Growth through Innovation
  - Driving domestic Growth and Employment
- Developing New Sources of Energy
  - Commercializing renewable alternatives to oil
- Addressing Climate Change
  - Growing a Green Economy; A major Growth opportunity
- Delivering Global Health
  - Transforming large investments in research to affordable and personalized treatment and care
- Improving Security

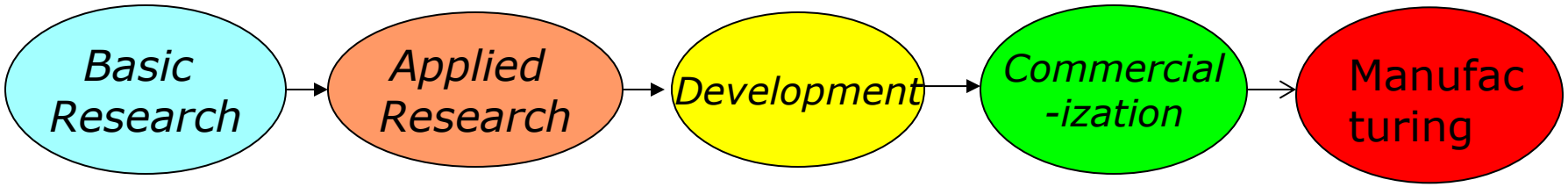
Leading Countries and Regions are Responding to the Innovation Challenge

- They are providing five things:
  - High-level Focus on Growth and Strength
  - Sustained Support for Universities
  - Rapidly Growing Funding for Research
  - Support for Innovative Small Businesses
  - Government-Industry Partnerships to bring new products and services to market
- They are investing very substantial resources to create, attract and retain the industries of today and tomorrow.

What is Innovation?

- The transformation of research ideas into new products, services, or improvements in organization or process
  - Some innovations are incremental
  - Others are disruptive, displacing existing technologies
- Complex activity involving coordination across multiple actors.

The Linear Model of Innovation



- Myth: Innovation is a Linear Process leading to Commercialization and Manufacturing
- False Implication: These are discrete & separable processes
- Reality: Innovation is a Complex Process

Implications for Policy Development

- Push on inputs: Reliance on Funding for Basic Research
- Pull on outputs: Create markets through procurement and the development of standards
- Belief that the processes are separable.
- Relatively little attention to the challenges of cooperation.

What are the Real World Implications of this World View?

The Case of Manufacturing

What Happens when you Separate Manufacturing from R&D?

- R&D and Supply Chains are tightly linked to manufacturing
  - Manufacturing is supported by an ecosystem of skilled workers, supplier firms, universities, research organizations, entrepreneurs, knowledge, and resources
- Off-shoring manufacturing pulls knowledge, R&D, and supply chains off-shore.
- In turn, this attracts more manufacturing off-shore
- The result is a loss of wealth creation, employment, and knowhow for the U.S.

Products invented in the U.S., but made in Asia

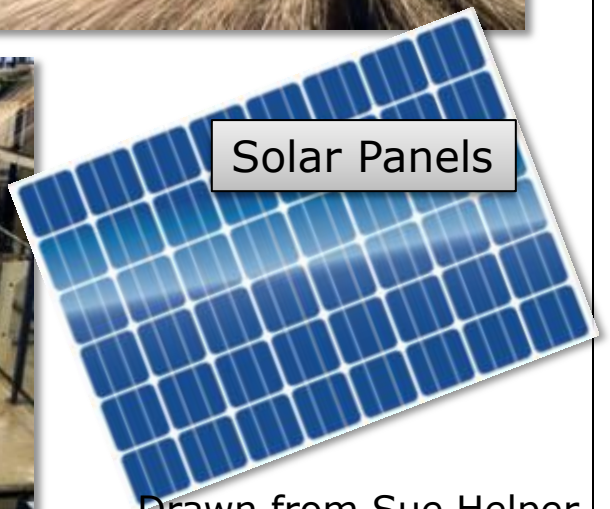
Consumer Electronics

Displays

Metal Castings

Lithium ion batteries

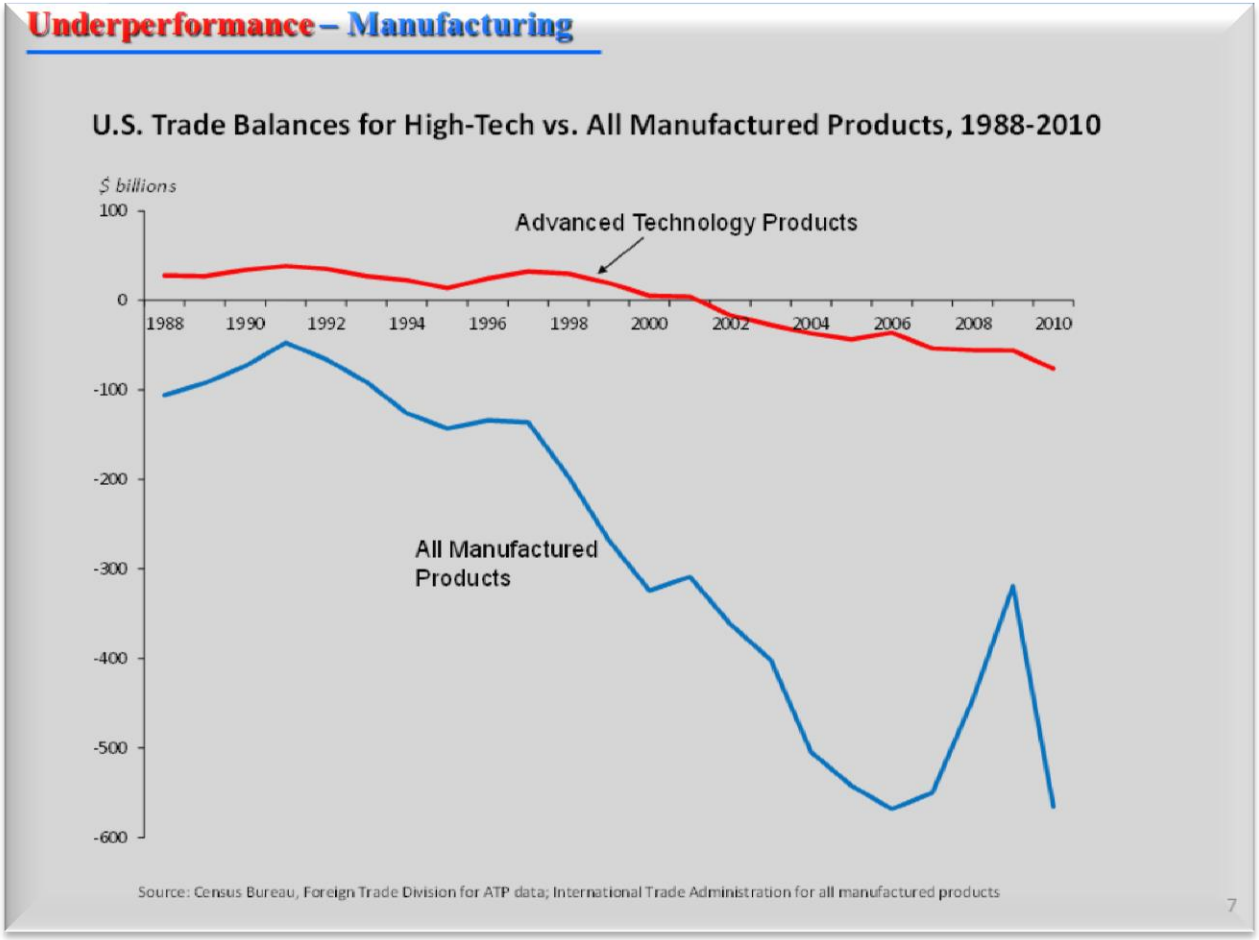
Machine Tools



Solar Panels

Drawn from Sue Helper

Declines in U.S. Trade Balance for Manufactured Products



Erosion of America's high-tech manufacturing base can undermine U.S. leadership in next-generation technologies.

It Matters where it is Made:

"The loss of companies that can make things will end up in the loss of research that can invent them."

Suzanne Berger et al.,
Production in the Innovation Economy
MIT Press, 2013

Reality: Innovation is a Complex Process

- Overlap: Major overlap between Basic and Applied Research, as well as between Development and Commercialization
- Mobility: Principal Investigators and/or Patents and Processes are Mobile, i.e., not firm-dependent
- Eureka: Many Unexpected Outcomes
- Non-Linear: Technological breakthroughs may precede, as well as stem from, basic research
- Inter-linkages: Manufacturing and R&D are tightly linked
- Collaborative: Multiple actors need to cooperate across the innovation ecosystem—this is hard.

The Innovation "Ecosystem"

- Polycentric: The U.S. 'innovation system' consists of multiple centers of activity that are loosely organized but often highly entrepreneurial. --Charles Vest
- Complex: Characterized by knowledge flows among complex, inter-linked, and often ad hoc ecosystems.
- Multiple Actors: Key actors include universities, corporations, small businesses, government organizations

What are the implications of this ecosystem perspective for policy?

How can we understand this complexity?

What can economics tell us?

The Austrian Perspective

- The Austrian School originated in late-19th and early-20th century Vienna
  - Carl Menger, Eugen von Böhm-Bawerk, and others
- Focus on subjective choices of individuals
  - Including individual knowledge, time, expectation, and other subjective factors.
- Focus on the social outcomes of individual choice.
  - Catallaxy: "order brought about by the mutual adjustment of many individual economies in a market." Hayek, von Mises
  - Differs from other schools of economic thought that focus on aggregate variables and equilibrium analysis.

The Public Choice Perspective

- Collective Action Situations exist where contributions from multiple actors are required to produce joint outcomes
- Collective Action Problems occur when unresolved
  - Motivation Problems and
  - Information Problems

…create sub-optimal outcomes

Motivation problems

- Social Dilemmas: Potential conflict between individual gain and collective benefits
  - Provision of public goods (public safety, health, knowledge, etc.)
  - Provision and maintenance of common-pool resources (protection of forests, wildlife, species, lakes, rivers, oceans, atmosphere, skilled labor pool, manufacturing commons)
- If benefits can be obtained by an actor without contributing, temptation always exists to free ride on the efforts of others. May also face overuse.

Information problems

- Missing information
  - Time and Place Knowledge
  - Knowledge of local realities, rules, and relationships
- Asymmetric information
  - Moral Hazard
  - Principle-agent problems
  - Signaling Problems
  - Fiscal Illusion

Well-designed Institutions Solve Collective Action Problems

- By structuring human interaction, institutions
  - Help each anticipate the actions of others
  - Reduce uncertainty, promote coordination and cooperation.
  - Realign incentives

The Ecosystem Perspective

- Institutions, together with various physical and socioeconomic variables, affect the performance of innovation systems
- How can this advance S&T policy?
  - Need to identify key Collective Action Problems.
  - Need to design institutional solutions to align incentives.

A Leading Example

Motivating the Commercialization of University Research
The Role of Bayh-Dole

Universities in the Postwar Era:1960 to 1980

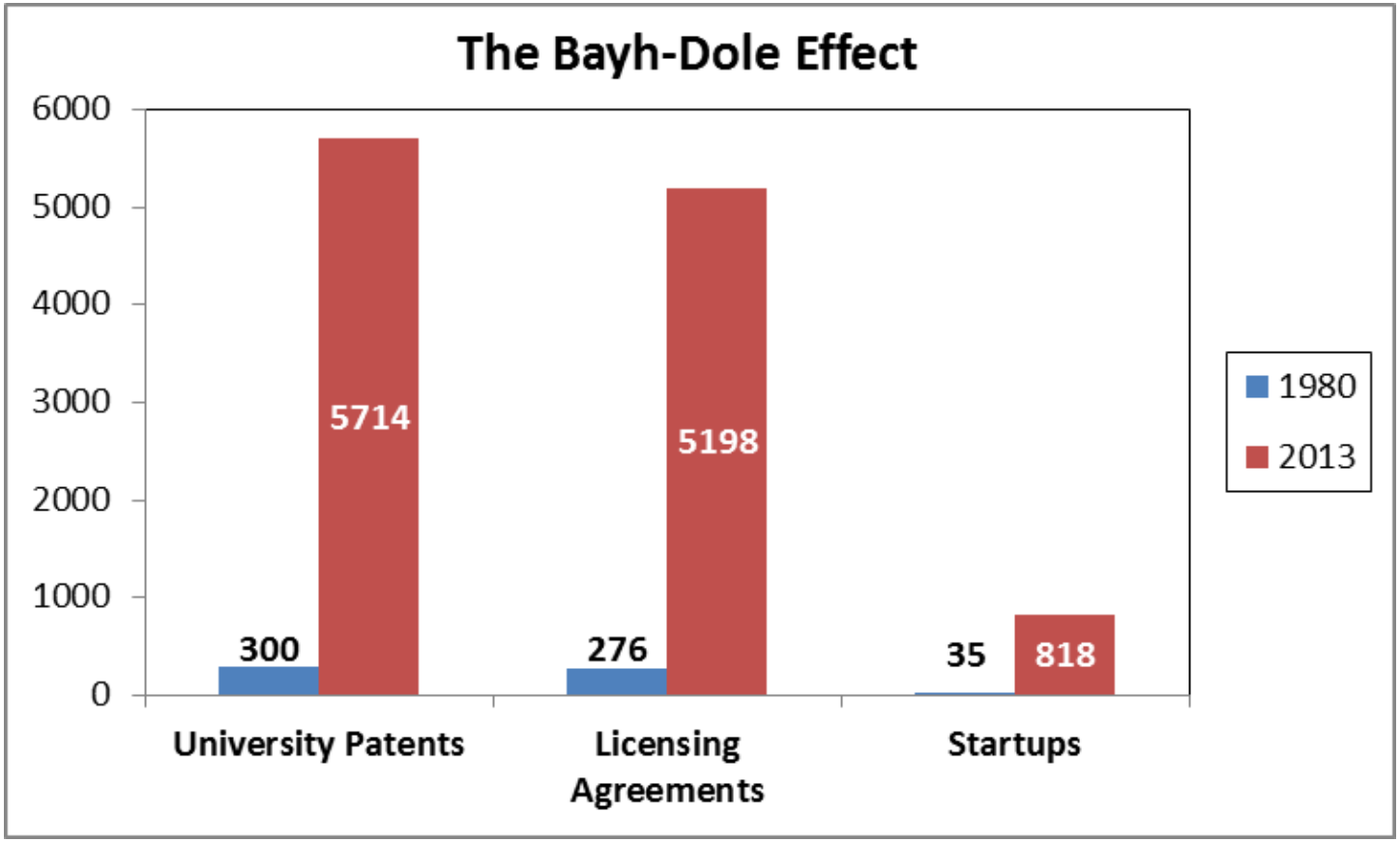
- In the United States, Industry, university, and Federal laboratory researchers did not always collaborate
  - Industry relied on corporate labs
  - Companies attracted university graduates but normally did not fund university research
  - Antitrust laws were presumed to prohibit joint research
- Patents from Federally funded research were generally held by government and not used
  - Universities did not actively seek patents until the 1970s.

In the U.S., the 1980 Bayh-Dole Act Created Incentives for Commercialization

- Bayh-Dole encouraged universities to patent results of federally funded research*
  - Transferred rights to intellectual property generated under federal grants to the universities
  - Academicians can profit from the market transfer of their work.
  - Universities can earn royalties by licensing research innovations to private companies

* M Feldman, I Feller, J Bercovitz, R Burton - Management Science, 2002

Impact of Bayh-Dole Took Time, but Change is Now Clear for U.S. Universities



Source: AUTM U.S. Licensing Activity Survey, 2013

Qualifying Bayh-Dole's Impact

- Growth in university patents and licenses in the U.S. have also been spurred by:
  - Significant growth in federal financial support for basic biomedical research in universities
  - Court rulings and shifts in federal policy that make it easier to patent biomedical research results
  - Laws strengthening intellectual property protection
- Bayh-Dole is a part of a long-term trend in more robust university–industry research linkages
  - Source: Mowery, Nelson, et al., Research Policy, 2001

Collective Action Problems in Innovation

- Key challenges in university-industry cooperation include:
  - Who should contribute what, where?
  - Who will coordinate their efforts?
  - How will joint returns be distributed?
  - How are faculty rewarded?
- Role of institutions
  - Help align incentives to solve diverse problems of collective action
  - Limits of the TTO solution

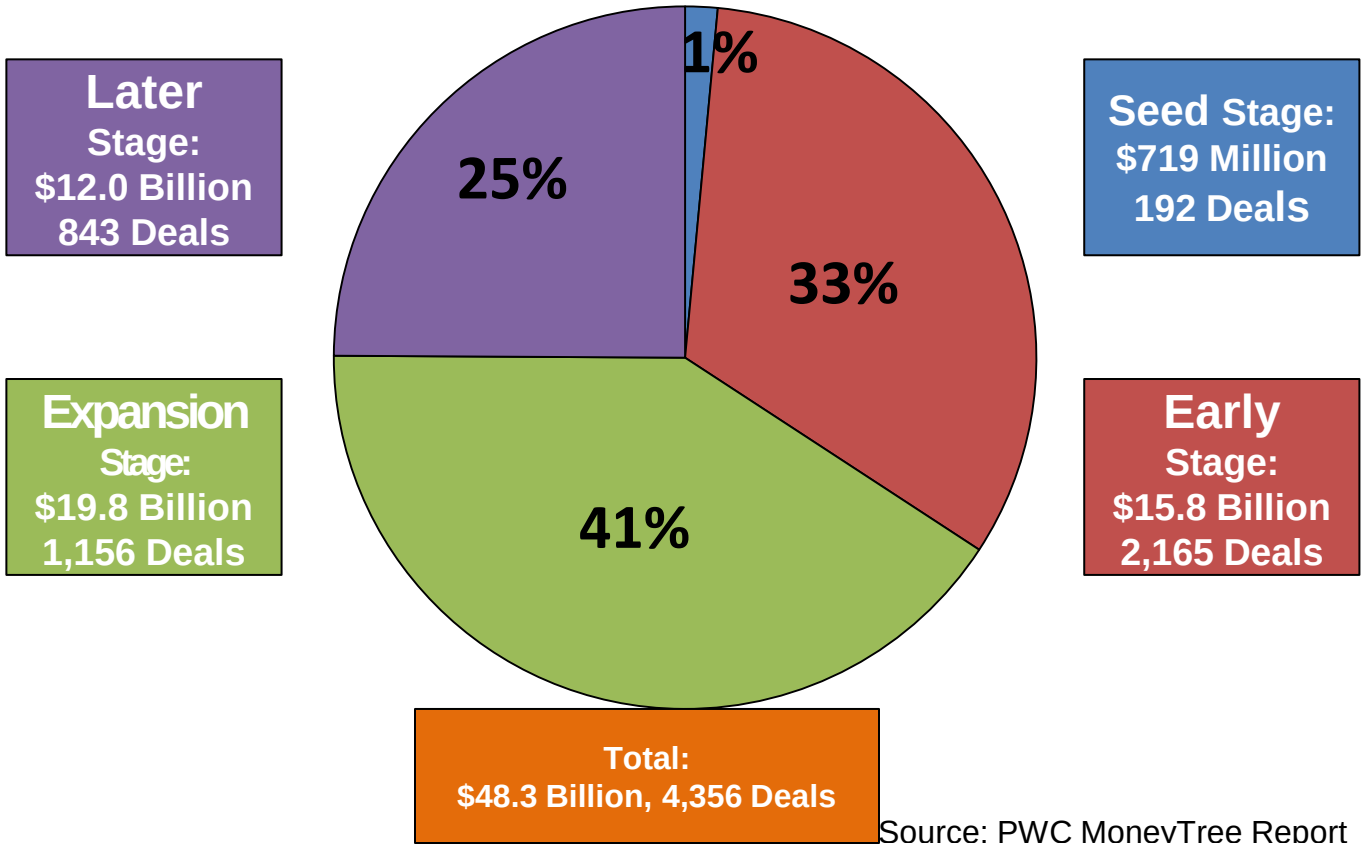
Another Collective Action Challenge for Innovation

Small Businesses, Information Asymmetries, and the Venture Capital Market

Small Companies Drive High-Technology Innovation

- Small Companies are Key Players in Bringing New Technologies to Market (Audretsch & Acs)
  - Large returns to national economic and strategic capabilities can result from relatively small national investments
  - Innovations—with the right policy support—can become new products and services for the market and provide support for government missions
- But small companies don't have the capital needed to transform ideas into innovations

U.S. Venture Capital Investments by Stage (2014)

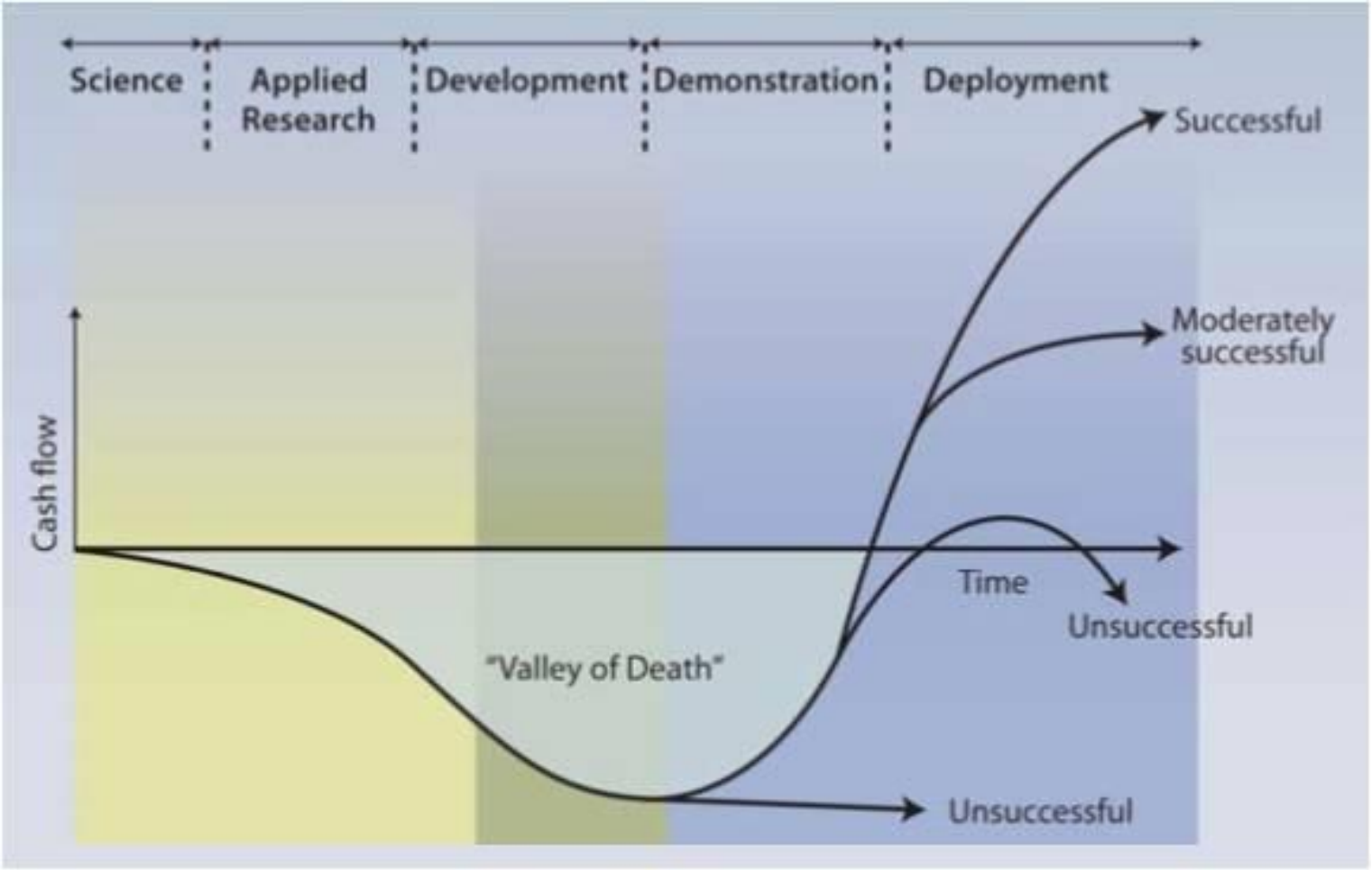


Source: PWC MoneyTree Report

The Myth of Perfect Venture Capital Markets

- Myth: "U.S. VC Markets are broad & deep, thus there is no role for government awards"
- Reality: Venture Capitalists have
  - Limited information on new firms
  - Prone to herding tendencies
  - VC investments have moved towards later, less risky stages of technology development
  - Limited investments in the seed stage of investment—$719 million (192 deals) in 2014:
    - Important but not the drivers of the U.S. economy

The Valley of Death: A Major Challenge for Innovators



The Role for SBIR

- Competitively awarded support for technological innovation
- Uses up to three phased awards from federal research funds to address government mission needs: phases limit risk and cost.
- Validation of technological capability and market potential help small businesses attract additional sources of funding.

So, what's new?

- Par ma foi, il y a plus de quarante ans que je dis de la prose, sans que j'en susse rien!
  - Molière

We need to draw from experience and theory to design policies for the innovation ecosystem.

New Areas for Analysis for STEP

- Investing in the Manufacturing Commons
  - NAS Study on Flexible Electronics
  - National Network of Manufacturing Institutes
- Fostering the "Middle Skills" workforce
  - A new Academies Study
- Growing Innovation Clusters
  - More than Real Estate developments
  - How to develop communities of trust
- Review of Public Private Partnerships
  - New Academies review of ARPA-e

Thank You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