The Challenges of 'Tough Tech': The American Venture System and National Competitiveness

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Private Capital Project at Harvard Business School
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Summary:

- Over recent decades, there's been a noticeable shift in venture capital financing, with a predominant focus on software and internet-related applications. This trend is largely attributed to the significant returns venture capitalists have achieved from such investments, especially when compared to returns from other technological sectors.
- This concentrated focus on software and internet domains has inadvertently created challenges for young firms working on other critical technologies. Innovations in areas like advanced materials and computer hardware often find it difficult to secure the necessary financing for commercialization.
- As a result of these financing challenges, many promising "tough tech" ideas and innovations never make it past the lab or prototype stage. This gap in funding and support has also created opportunities for adversarial countries to step in, potentially capitalizing on these innovations.
- The "tough tech" industry holds immense potential for driving innovation and economic growth in the U.S. Its success is contingent upon sustained support from the private sector, especially for high-risk yet high-impact ventures. The U.S. government plays a crucial role in nurturing early-stage technologies, fostering human capital development, and aiding in the industry's scale-up phases. While foreign investment can bridge the current funding gap, it's imperative to strike a balance—ensuring intellectual property protection while still reaping the benefits of global markets and collaborative scientific endeavors.

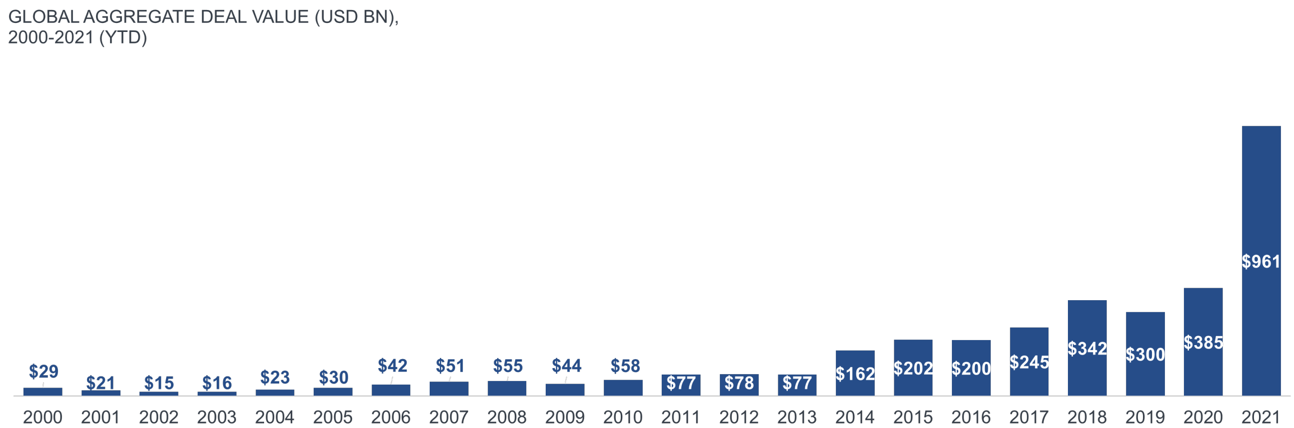
Introduction

The success of the venture capital industry over the past decade has resulted in capital pouring into the sector, particularly in recent years. Figure 1 shows the tremendous growth in inflows to venture-backed firms globally, which climbed from $385 billion in 2020 to $961 billion in 2021.

But while the VC industry has continued to fund highly innovative companies, it has focused on a narrower slice of technology in the past decades. Figure 2 shows that venture firms have increasingly focused on asset-light, scalable technologies, including software and services, that lend themselves to “lean startup” approaches. This focus has led to a smaller share of capital going to critical areas of cutting-edge science and technology. Thus, essential sectors that could have substantial social benefits often have difficulty accessing capital.

Figure 1

Global Inflows into Venture Capital-Backed Firms, 2000-2021

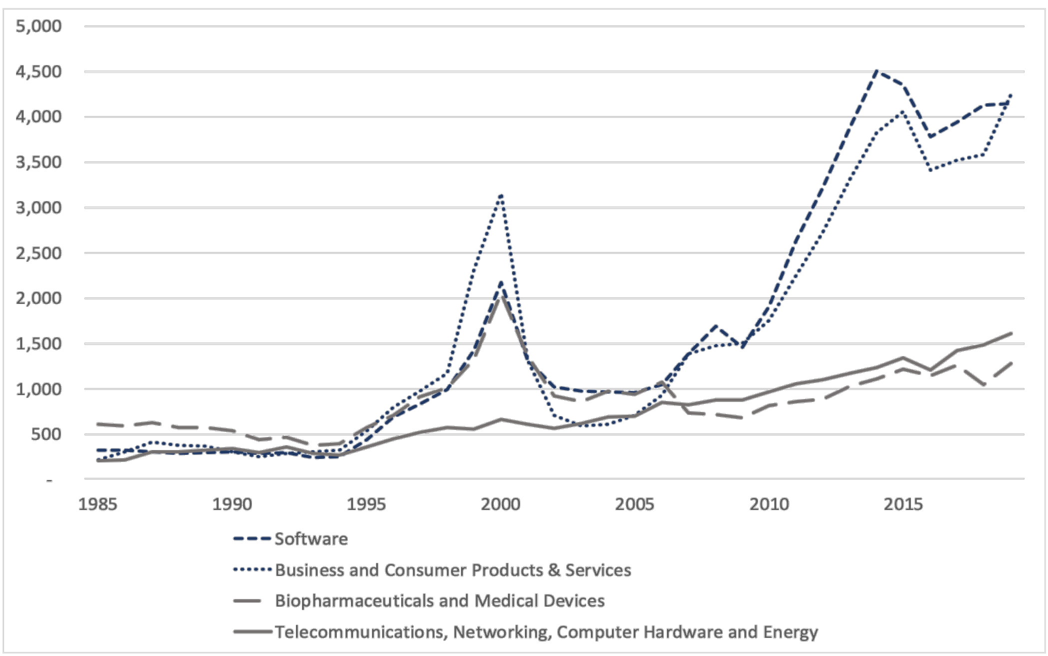


Source: Preqin, accessed December 30, 2021. Includes funds invested in venture-backed by non-venture investors (i.e., mutual, hedge, and sovereign wealth funds).

Figure 2

Technology Focus of VC

Number of U.S. startups receiving a first round of financing from VC, 1983 – 2019 by sector



Source: Josh Lerner and Ramana Nanda, "Too Much of a Good Thing? The Venture Capital Boom and Its Consequences for Innovation," *Journal of Economic Perspectives,* 2020.

Challenges

This paucity of capital reflects numerous challenges that make it difficult to invest in the tough tech industries.

Large Capital Requirements

One of the major challenges with "tough tech" investing is the need for significant capital in the development stages of these companies before they are ready to deliver functioning (let alone scalable) products. This need for early capital expenditures stands in stark contrast to other industries such as software, which have increasingly relied on methods to stay asset-light in their early stages of experimentation. In addition, tough tech industries have a higher degree of technical risk ("will it work?") to go along with the standard startup commercial risk ("will customers want to pay for it?"). They often require more physical development (i.e., building prototypes, accessing new materials, utilizing a chemistry lab, a machine shop, or some specialized equipment) to turn their innovation into commercial use. Beyond their own specific development, deploying these technologies often involves integration with complementary technologies and paving new regulatory paths.

Long Cycle Time of Experimentation

Another challenge is the long cycle time of experimentation in tough tech industries. Many such inventions do not initially have a proven commercial use, just a variety of potential applications. In creating new systems for critical industries like healthcare, energy, and defense, tough tech ventures often face a high bar for proving their value to customers and regulators. While operating at the frontier of science and engineering, the process of testing these concepts is frequently laborious and drawn out, so the companies often cannot cheaply reach milestones as software firms frequently do. Finding investors who have the patience for unproven technologies with long and frequently indeterminant development cycles is extremely difficult.

Scale-up Challenges

Once an application for new tough technology is proven, the next challenge is how to scale up the technology for commercial use. This phase of business is frequently complicated. In the initial prototype development, perhaps, a firm might be able to make a couple of micrograms of something critical to its technological development. To make that in metric tons annually, however, is an entirely different issue requiring access to sufficient raw materials, and reliable quality-control and manufacturing processes.

Another challenge is that during the scale-up phase, firms face pressures to manufacture in the cheapest place, often abroad. Manufacturing abroad could also create national security concerns. Such an approach may lead to knowledge spillovers abroad since much of the critical learning takes place during the scale-up and manufacturing process.

A Decline in Business Dynamism

More generally, the U.S. economy has experienced a significant rise in market concentration in recent years. According to many different indicators, there has also been a decline in business dynamism. For example, the share of jobs in new companies (those under five years old) dropped from 16% in 1980 to under 10% in the 2010s.[1] Part of the reason is that many new talented entrepreneurs are shying away from challenging the larger market incumbents or have their new ventures ultimately acquired by these firms. In addition, government research and development spending, which played a crucial role in spawning industries such as biotechnology and the internet, has been declining for some time in inflation-adjusted terms. Lastly, there are also human capital considerations in the supply of research scientists.

Overcoming the Challenges in the Tough Tech Industry

The list of challenges delineated above may seem daunting. But the following are some ways to overcome the challenges in the tough tech industry.

Seek Foreign Investors

One solution to overcome the funding challenges of tough tech is to seek foreign investors, who often seem to be willing to invest in tough tech firms than U.S. ones. This solution, however, presents some concerns. First, foreign investors could gain access to information that would help close the technology gap with the U.S. Academic researchers find that foreign countries with a larger technology gap tend to invest more in the U.S.[2] Instead of doing costly research in their own country, foreign investors fund projects directly at the source and try to learn from those experiences. And indeed, once a foreign country starts investing in the U.S., the patenting in that foreign country increases. These concerns about foreign capital are particularly intense when it comes to technologies with national security applications. However, if investments are structured correctly and the motives of foreign investors are clear, there may not be any issues.

Government Policy

Governments can also be part of the solution to the difficulties in the tough tech industry. They can help bring more capital, encourage talent, and support the idea pipeline in the tough tech domain. In the U.S., a substantial amount of money flows into early-stage tough tech start-ups through the Small Business Innovation Research ("SBIR") grants administered by the Small

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[1] Decker, Ryan A., John Haltiwanger, Ron S. Jarmin, and Javier Miranda, "Changing Business Dynamism and Productivity: Shocks versus Responsiveness." *American Economic Review*, 110 (2020), 3952-90.

[2] Akcigit, Ufuk, Sina Ates, Josh Lerner, Richard Townsend, and Yulia Zhestkova, "Fencing off Silicon Valley: Cross-Border Venture Capital and Technology Spillovers," NBER Working Paper Series 27828, http://www.nber.org/papers/w27828.

Business Administration of the U.S. government. However, these grants are relatively small and tend to be widely spread across technologies rather than targeting the most promising emerging ones. In addition, these grants are more apt to focus on research rather than product development.

The U.S. Department of Defense has launched a funding program called the National Security Innovation Capital, which focuses on helping dual-use hardware startups in the most critical emerging technology areas speed up the development of their products. It has demonstrated early success but has limited funding.

Other countries have implemented similar programs. For example, the Australian and U.K. Governments both funded the creation of a public-private partnership venture fund whose purpose is to take advantage of the technology and inventions developed by different national labs and build companies out of them. In addition, a group of 19 NATO countries has committed a billion euros to invest in early-stage hard tech start-ups.

The panelists agreed that government programs need to be more flexible, more targeted, and write larger checks in this space. Avoid "capture" by less innovative firms is also an issue.

Stoking Demand for Tough Tech

Governments can do more to stoke the demand side of tough tech and facilitate the transition of successes into global commercialization and scale. The government can play a role as a direct buyer of new technologies or support companies to be a buyer on behalf of the government (see, for instance, the experience of low-earth orbit satellite developer Hedron). This role can help reduce the initial market risk before the technology is mature enough for the large-scale commercial market. Beyond supporting specific supplier companies, purchasing key technologies from new technology ventures signals to the next generation of startups that inventing for these areas is a viable commercialization strategy.

In addition, the government can help start-up firms be aware of who those buyers are within the government. For example, NASA had shifted the development of technologies for space to the private sector when previously it was an exclusively governmental sphere. In essence, NASA helped create the beginnings of an ecosystem that is both commercial and national security oriented. In the case of the Defense Department, there is a dependence on large contractors to do the work to get products to market. This dependence, however, is starting to change. There are increasing avenues for public capital to flow to small-scale ventures to help deliver products for commercial and defense applications.

Developing Human Capital

The tough tech industry relies heavily on highly skilled scientists and engineers to produce innovative ideas and figure out ways to commercialize those ideas. Academic studies argue that innovation policy should focus on increasing the number of scientists and engineers available to the private sector, rather than subsidizing the private sector's demand for scientists.[3] Given that the labor supply of scientists and engineers is relatively inelastic, when a government funds R&D, a significant fraction of the increased spending goes directly into higher wages and not to more creative output. In addition, by raising the wages of scientists and engineers, even for firms not receiving federal support, government funding directly "crowds out" private inventive activity.[4]

Instead, Governments should focus on equal access to education and ways to develop more Ph.D.s., as most radical patents come from well-trained Ph.D.s. For instance, in early 2000, the Danish government allocated a significant amount of funding for Ph.D. training and subsidized the Ph.D. hiring by firms to boost innovation in general.

Another area for education relates to private investors. Some venture firms are increasingly interested in tough tech investing, particularly the application of software to these industries, but more needs to be done. The education of private and public sector investors will be key to the success of the tough tech industry, just as it was for the biotechnology industry decades ago.

Conclusion

The tough tech industry has produced some ground-breaking technologies and will continue to be paramount for innovation and economic growth in the U.S. The success of this industry hinges on the ability of the willingness of the private sector to support such technically risky, but high impact firms in the long run, as well as the U.S. government providing support for early technologies, developing human capital, and even facilitating the scale-up phases of the industry. Foreign investment into the sector will be necessary to fill the funding gap in the near future but must be carefully managed to protect intellectual property without blocking the benefits of international markets and scientific collaboration.

[3] Romer, Paul M., "Should the Government Subsidize Supply or Demand in the Market for Scientists and Engineers?," *Innovation Policy and the Economy*, Volume 1, National Bureau of Economic Research, 2000.

[4] Goolsbee, Austan, "Does Government R&D Policy Mainly Benefit Scientists and Engineers?," *American Economic Review Papers and Proceedings*, Volume 88. No. 2, May 1988.