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What I Learned by Doing Capitalism

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In 1971, I left Cambridge University with a doctorate in Economics and an extraordinary intellectual endowment. Supervised by Richard Kahn, I had passed four years immersed in the economics of Keynes – *not*, that is to say, Keynesian Economics. This meant recognition, first, of the integration of economics and finance at every level, from the most micro scale of the individual consumer, entrepreneur and – especially – investor to the aggregate scale of the macroeconomy. Second, it carried with it a profound skepticism with respect to the notion of efficient markets and the promise of stable equilibrium. Third, it meant recognition of the inescapable ontological uncertainty under which economic and financial decisions are made. In consequence, I found that I could not teach Samuelson's Neoclassical Synthesis, which what was on offer in the Departments of Economics across America.

So, leaving academia, I stumbled into the Innovation Economy by way of joining one of the many private investment banking firms that populated Old Wall Street, all subsidized by the fixed brokerage commissions imposed by the New York Stock Exchange. F. Eberstadt & Co. was distinguished by its exclusive focus on the science-based industries: from chemicals to pharmaceuticals and on to electronics and computing. This, I must add, was when sellside investment research was still an honorable profession. Thus, Doing Capitalism at F. Eberstadt offered a privileged opportunity to learn the dynamics of the process through which technological innovation transforms the market economy.

The Innovation Economy begins with discovery and culminates in speculation. Over some 250 years, economic growth has been driven by successive processes of trial and error and error and error: upstream exercises in research and invention, and downstream experiments in exploiting the new economic space opened by innovation. Each of these activities necessarily generates much waste along the way: dead-end research programs, useless inventions and failed commercial ventures. In between, the innovations that have repeatedly transformed the architecture of the market economy, from canals to the internet, have required massive investments to construct networks whose value in use could not be imagined at the outset of deployment. And so at each stage, the Innovation Economy depends on sources of funding that are decoupled from concern for economic return.

Upstream, when mechanical tinkering yielded to scientific discovery as the basis for commercial innovation, funding initially was supplied by the great monopolies spawned by the second industrial revolution. These corporations, supported or at least tolerated by the state, channeled a portion of their profits into central research laboratories. Over a long generation their seemingly unassailable market positions were lost to competition or deregulation. But by then a cadre of political entrepreneurs had successfully invented national security and human health as legitimizing rationales for direct state investment in science.[1]

The transformational networks that implement the Innovation Economy can be planned, built and funded by the state: the U.S. interstate highway system is an outstanding example. They can also be planned, built and funded by the willing collaboration of promoters and speculators: the original British railway system is the exemplar here. In each case, the calculus of expected economic return was a secondary consideration. Hence the endless miles of superhighway crossing the empty wastes and wilderness of the American West and the multiplication of competing routes and destructive competition that followed hard on the British railway mania of the 1840s.

Downstream, the Innovation Economy is driven by financial speculation. Throughout the history of capitalism, financial bubbles have emerged and exploded wherever liquid markets in assets exist. The objects of speculation have ranged across a spectrum that challenges the imagination: from tulip bulbs, to gold and silver mines, to the debt of newly established countries of unknowable wealth and—again and again—real estate and the shares that represent ownership of corporations. The central dynamic is that the price of the financial asset is separated from concern with the underlying cash flows—past, present or possible future—generated by the economic assets it represents. Speculators in the financial asset can - and often do - profit, even when the project they have financed fails. Inevitably, the speculation collapses: the more it has been fueled by credit and has infected the banking system, the more disastrous the economic consequences and the broader and more urgent the pleas for public relief.

Occasionally, decisively, the object of speculation is the financial representation of one of those fundamental technological innovations—canals, railroads, electrification, automobiles, airplanes, computers, the internet—deployment of which at scale transforms the market economy. From the wreckage of the financial bubble, as Carlota Perez has illustrated, a "new economy" emerges.[2] [**SLIDE 2 HERE**]

Both upstream and downstream, absence of market discipline is the essence of the process. For contrary to the central dogma of neoclassical economics, efficiency is not the virtue of a market economy when growth is driven by that creative destruction identified by Schumpeter as the engine of economic development.[3] The prime virtue is the ability to tolerate unavoidable waste.[4] So the state has become central to the Innovation Economy's dynamics: to fund the upstream research that generates discovery

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[1] See D. M. Hart, *Forged Consensus: Science, Technology and Economic Policy in the United States, 1921–1953* (Princeton University Press, 1998), pp. 145–234.

[2] C. Perez, *Technological Revolutions and Financial Capital: The Dynamics of Bubbles and Golden Ages* (Cheltenham, UK: Edward Elgar, 2002).

[3] J. A. Schumpeter, *Business Cycles: A Theoretical, Historical and Statistical Analysis of the Capitalist Process* (London: McGraw-Hill, 1939), chapters 1–3, and, also by Schumpeter, *Capitalism, Socialism and Democracy,* 4th edn. (London: Allen & Unwin, 2010 [1943]), part II: "Can Capitalism Survive?"

[4] For a comprehensive analytical review of the literature on technological innovation as an evolutionary process, see G. Dosi and R. R. Nelson, "Technical Change and Industrial Dynamics as Evolutionary Processes," in B. H. Hall and N. Rosenberg (eds.), *Handbook of the Economics of Innovation*, 2 vols. (Amsterdam: North-Holland, 2010), vol. I, pp. 51–127.

and invention, to support the deployment of new networks, to serve as a creative customer for the new products and services generated - and to preserve continuity in the market economy when the speculative bubble that has funded its transformation bursts.

I have come to read this history as driven by three sets of continuous, reciprocal, interdependent games played between the state, the market economy and financial capitalism.[5] Through the centuries, the state and the market economy have variously collaborated and competed in the allocation of resources and the distribution of income and wealth. And financial capitalism is ever ready to exploit discontinuities in market and political processes, while it depends on those same processes for its prosperity and even at times for its survival.

Thus, over some 250 years, the Innovation Economy has been driven by a Three-Player Game. In this lecture, I will explore the dynamics of the Game through the lens of U.S. venture capital, drawing on some forty years of work as a theorist-practitioner. Examining the context in which the venture capital industry emerged and – for a brief two decades – flourished can illuminate both its own limited role and that of the two institutions on which it has depended.

In 1980, following regulatory amendments to allow pension funds to invest in such risky assets as venture capital, the total capital committed to member firms of the National Venture Capital Association (NVCA) was $2 billion, about $5.5 billion in 2010 dollars. **[SLIDE 3 HERE**] Twenty years later, in 2000, from a relatively stable range of only $5–10 billion (in then-current dollars) from 1985 to 1995, the flow of funds to venture capital peaked at no less than $105 billion. Access to the stock market for new, venture-backed companies was almost continuous, punctuated by several hot IPO markets and culminating in the great dotcom/telecom bubble of 1999–2000. [**SLIDE 4 HERE]** To provide some sense of scale, the total amount of capital raised in all venture-backed IPOs in the mini-bubble year of 1983 was $3.8 billion, slightly more than $10 billion in 2010 dollars. The amount raised in 1999 and 2000 was $21 billion and $25.5 billion, respectively, before retreating to pre-Bubble levels and then collapsing with the onset of the Financial Crisis in 2008.[6]

Here we have a flag for identifying the factor that has dominated venture returns over the past generation, namely, the state of the public equity markets and, especially, the market for Initial Public Offerings. Looking across the entire span from 1980 to the post-bubble era, the dependence of venture capital returns on access to the IPO market is clear. My own research, in collaboration with Professor Michael McKenzie of the University of Sydney, characterizes each quarter since the start of 1980 by the number of venture-backed IPOs and the proportion of them that were for companies not yet profitable. McKenzie and I employed these figures to generate an index of IPO market speculation. [**SLIDE 5 HERE**] We found that when distributions back to the investors coincided with IPO market conditions

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[5] For a set of relevant case studies that stops short of offering a comprehensive framework, see. R. Sylla, R. Tilly and G. Torella, *The State, the Financial System and Economic Modernization* (Cambridge University Press, 1999).
[6] National Venture Capital Association, *2010 Yearbook* (New York: Thomson Reuters, 2010), pp. 15, 19, 28, 43–46, 49–54.

characteristic of a bubble, the median internal rate of return for the funds in our sample was 76 percent; when exits occurred under poor IPO market conditions, the median return was only 9 percent.[7]

The impact of the bubble and its aftermath on the profile of venture capital returns is enormous. From the incipient emergence of a venture capital industry in 1981 through funds launched in 1994, the aggregate distributions of venture capital firms to limited partners (net of fees and carried interest) amounted to 3.24 times the capital they had committed to the funds. For the 1995 vintage, the multiple reached 5.99 times, and it was 5.03 for the 1996 vintage. However, from the 1998 vintage on, the aggregate Total Value to Paid-in Capital ratio for members of the NVCA has never exceeded 1.5 times. [**SLIDE 6 HERE**] The ten-year return on the US Venture Capital Index turned negative as of the end of 2009 and declined at a compound annual rate of 2 percent through 2010, before turning modestly positive (4.4 percent versus 5.3 percent for the NASDAQ index) through the first quarter of 2012.[8] Correlated with the decline in venture returns since 2000 is the sharp and prolonged decline in the IPO market, from an average of 547 IPOs per year during the 1990s to 192 per year since 2001.[9]

After a post-bubble rebound in the mid-2000s, new commitments to venture funds have declined sharply: to $16 billion in 2009, $14 billion 2010 and $18 billion in 2011.[10] Mark Heesen, president of the NVCA, [**SLIDE 7 Here]** summarized the state of the industry when he presented the data on 2011fundraising, concluding:

> This past year we saw more venture capital money raised by essentially the same number of firms, a sign that consolidation within the industry is continuing. We also continued to invest more money in companies than we raised from our investors. Both of these trends—if they continue—suggest that the level and breadth of venture investment is starting to recalibrate to reflect a concentration of capital in the hands of fewer investors. Our cottage industry is indeed getting smaller still and that will impact the startup ecosystem over time.[11]

The dependence of venture capital returns on the state of the IPO market at time of exit is one of four stylized statistical facts about venture capital. The second one, widely recognized, is the extraordinary skew in such returns: a very small number of venture capital funds and firms drive the aggregate returns for the industry as a whole. **[SLIDE 8 HERE]** In the database of 205 venture funds that

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[7] M. D. McKenzie and W. H. Janeway, "Venture Capital Funds and the Public Equity Market," *Accounting and Finance,* 51, no. 3 (2011), pp. 764–786.
[8] Cambridge Associates LLC and National Venture Capital Association, "Venture Capital Performance Continues Gradual Improvement in First Quarter of 2012,"press release, July 30, 2012, available at www.nvca.org/index.php?option=com_content&view=article&id=78&Itemid=102.
[9] IPO Task Force, "Rebuilding the IPO On-Ramp: Putting Emerging Companies and the Job Market Back on the Road to Growth," presented to the U.S. Department of the Treasury, October 20, 2011.
[10] Thomson Reuters and National Venture Capital Association, "Venture Capital Firms Raised $5.6 billion in Fourth Quarter, as Industry Continued to Consolidate in 2011," press release*,* January 9, 2012, available at www.nvca.org/index.php?option=com_content&view=article&id=78&Itemid=102.
[11] Ibid.

McKenzie and I analyzed, the mean internal rate of return was 47 percent. However, the mean rate of return realized by the top decile of funds was no less than 215 percent; excluding these twenty funds from the sample dropped the mean return to 27 percent.[12]

The monotonic increase in returns through the four periods broken out might suggest that venture capitalists had been successfully “learning by doing”: wrong! Even with the top funds included, the returns realized by the funds McKenzie and I studied were broadly comparable in statistical measure with the returns available from the public equity market as the stock market boom of the 1980s became the bubble of the late 1990s.

Because we had access to the actual, dated cash flows between the limited partners who provided us with the data and the funds in which they invested—a rare circumstance—we were able to compare the returns realized by these funds to what an investor would have received by investing in the public market. **[SLIDE 9 HERE]** Following Kaplan and Schoar, we created a synthetic alternative fund for each actual fund by “investing” the same number of dollars that went into that fund on each date into the NASDAQ index and withdrawing from the index the amount distributed back to the limited partner at each distribution date. The result was striking: while the *mean* return to the 136 actual venture funds was 1.59 times what would have been realized by investment in the index, when the top decile was excluded, that figure dropped to 1.02 times. And the *median* return of the entire sample of 136 funds, including the top decile, was exactly identical to what the public market would have delivered—and delivered with complete and continuing liquidity to the investing limited partner.[13]

These findings have recently been confirmed by the Kauffman Foundation, **[SLIDE 10 HERE]** the leading source of funding for academic research on entrepreneurship:

> The Kauffman Foundation investment team analyzed our twenty-year history of venture investing experience in nearly 100 VC funds with some of the most notable and exclusive partnership “brands” and concluded that the Limited Partner (LP) investment model is broken. Limited Partners—foundations, endowments, and state pension funds—invest too much capital in underperforming venture capital funds on frequently mis-aligned terms.[14]

The third stylized fact of venture capital is that—in contrast with all other asset categories—persistence can be detected in the returns of individual managers. Analysis of our data confirmed the findings of a survey of a broader sample of funds conducted by Kaplan and Schoar: performance of a

[12] McKenzie and Janeway, “Venture Capital Funds and the Public Equity Market,” p. 8.
[13] This methodology was developed by Steven Kaplan and Antoinette Schoar to characterize a large database of venture capital funds with comparable results; it was published in S. V. Kaplan and A. Schoar, “Private Equity Performance: Returns, Persistence and Capital Flows,” *The Journal of Finance,* 60, no. 4 (2005), pp. 1791–1823.
[14] Kauffman Foundation, “’WE HAVE MET THE ENEMY… AND HE IS US,’ Lessons from Twenty Years of the Kauffman Foundation’s Investments in Venture Capital Funds and The Triumph of Hope over Experience” (Kansas City MO, 2012).

given fund is a significant predictor of the returns realized by the next fund of the same managers.[15] Persistence in the success rate of serial entrepreneurs can also be discerned,[16] suggesting that superior venture capitalists and superior entrepreneurs establish a self-reinforcing positive feedback loop.

Taken together with the skew in returns and the correlation of fund performance with the public equity markets, the conclusion is evident: definition of venture capital as a distinct asset class to which capital should be allocated is, literally, a category error. Investment in the few persistently successful VCs represents an exceptional opportunity for those with access to them. But broad identification of venture capital as a superior asset class – let alone as a transformative instrument of state policy - misinterpreted what has proved to be a transient epiphenomenon, riding on the back of the greatest bull market in the history of capitalism.

The fourth stylized fact of venture capital has been barely touched by academic research and yet has the most profound significance for understanding how the Innovation Economy works. **[SLIDE 11 HERE]** Professional venture capitalists in the United States have concentrated their activities and earned their returns in a very small number of industrial domains. In the three decades since 1980, Information and Communications Technology (ICT) has accounted for 50 -75 percent of all dollars invested by members of the NVCA, with its average share usually hovering around 60 percent.[17] The ICT and biomedical sectors together have consistently accounted for 80 percent of all dollars invested by venture capitalists.[18]

Why has it been in the world of information technology and, secondarily, biomedicine that venture capitalists have been successful? In brief: only in these sectors of research did the state invest at sufficient scale in the translation from scientific discovery to technological innovation. Through the Defense Department and the NIH, that is, the federal government funded construction of a platform on which entrepreneurs and venture capitalists could dance.

Let's focus on ICT. National funding of the basic research that enabled the IT revolution was overwhelmingly provided by the Department of Defense. The Soviet threat, crystallized in the years following 1945 and amplified by the Korean War in 1950 and the launch of Sputnik in 1957, was the context for the US military's massive commitment to renewing its wartime role as the principal financier of technical research and the principal customer for the products generated therefrom.[19]

The scale of R&D funding was substantial: for twenty-five years through 1978, federal sources accounted for more than 50 percent of national R&D expenditures and exceeded the R&D expenditures

[15] M. D. McKenzie and W. H. Janeway, "Venture Capital Fund Performance and the IPO Market," Centre For Financial Analysis and Policy, University of Cambridge, Working Paper 30 (2008), p. 21 and Table IX.
[16] P. A. Gompers, J. Lerner, D. Scharfstein and A. Kovner, "Performance Persistence in Entrepreneurship and Venture Capital," *Journal of Financial Economics,* 96, no. 1 (2010), pp. 18–32.
[17] The standard deviation of the time series is only .09 over the period.
[18] National Venture Capital Association, *2010 Yearbook,* p. 31. The ICT sector includes Media and Entertainment, which didn't become a significant category until the mid-1990s. By that time (for venture capitalists, at least) it was embedded in the world of the internet.
[19] D. C. Mowery and N. Rosenberg, *Technology and the Pursuit of Economic Growth* (Cambridge University Press, 1989), pp. 126–128, 143–146.

of all other OECD governments combined.[20] As Henry Kressel, my partner at Warburg Pincus, would write in retrospect, drawing on his own entry into the digital research enterprise at RCA's Sarnoff Laboratory around 1960: "The real visionaries in the early days were to be found in U.S. defense organizations."[21]

By the mid-1950s, the Department of Defense had already funded some twenty research projects to construct digital computers,[22] even before the Soviet launch of Sputnik catalyzed creation of the Defense Advanced Research Projects Agency (DARPA). From microelectronics and semiconductor devices through computer hardware and software and on to the internet, development of all of the components of digital information and communications technology reflected state policies for both R&D and procurement that, **[Slide 12 Here]** as Fabrizio and Mowery write, the Defense Department

> encouraged the entry of new firms and interfirm technology diffusion. In addition, federal procurement supported the rapid attainment by supplier firms of relatively large production runs, enabling faster rates of improvement in product quality and cost than otherwise would have been realized. Finally, Federal support of innovation in IT contributed to the creation of a large-scale R&D infrastructure in federal laboratories and, especially, in U.S. universities.[23]

During prior technological revolutions that have defined the succession of new economies since roughly 1750, large-scale government support for the deployment of more or less proven technologies had been significant and at times decisive. Even in the United States, state credit was used to fund canal building and the gift of public lands subsidized railroad construction. But the post–World War II engagement of the US Department of Defense to finance both fundamental research at the frontier of science and the technological development necessary to produce reliable devices and systems was entirely unprecedented.

Much of the funding was directed to the industrial research labs of the great corporations—AT&T, IBM, RCA—whose monopoly rents had funded scientific advance and innovative engineering from the late nineteenth century to World War II. But much was distributed more broadly as well, especially to universities. Moreover, the corporate suppliers were required to share the results of research not only with each other but with new entrants. When their monopoly profits came under pressure beginning in the 1970s and all the industrial sponsors pressured their central labs for product-oriented applied R&D, the new academic networks of research and innovation were in place.[24]

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[20] *Ibid*., p. 283, and Mowery and Rosenberg, *Technology and Economic Growth*, p. 125.
[21] H. Kressel, *Competing for the Future: How Digital Innovations Are Changing the World* (Cambridge University Press, 2007), p. 13.
[22] K. R. Fabrizio and D. C. Mowery, "The Federal Role in Financing Major Innovations: Information Technology During the Postwar Period," in N. R. Lamoreaux and K. L. Sokoloff (eds.), *Financing Innovation in the United States, 1870 to the Present* (Cambridge, MA: MIT Press, 2007), table 7.2, p. 296.
[23] Ibid., 286–287.
[24] For an authoritative summary of the rise and fall of the industrial research laboratory as the locus for technological innovation, see Kressel, *Competing for the Future,* chapter 3. For an updated overview of the impact of military

In my own life as a practitioner, this dual dependency on speculation and the state was exemplified by the most successful investment I ever led: BEA Systems [*not* BAE!]. The story of BEA dramatizes the complex dynamics of the Innovation Economy. The source of its initial product was research funded by a state-sanctioned monopoly that, when liberated to compete commercially, had no idea how to do so. Its phenomenal growth was a function of the maturation of the internet, offspring of DARPA, as an environment for commerce. And the extraordinary investment returns that it delivered were due to the speculative excesses of equity investors who had recognized the emergence of a new, digital economy. BEA, that is to say, represented the apotheosis of the Three-Player Game's intersection with the Innovation Economy.

In 1995, Warburg Pincus backed three experienced executives, Bill Coleman, Ed Scott and Alfred Chuang – B-E-A. Our shared mission was to leverage the new generation of computing technologies in order to exploit IBM's version of the innovator's dilemma, its inability to cannibalize its own, hugely profitable franchises.[25] Together we identified a potentially enormous opportunity: to deliver software that would enable large enterprises to manage their "mission-critical" business transactions on the new distributed computing networks. We jump-started the venture by acquiring relevant technology called Tuxedo that had been developed by AT&T's Bell Labs, once AT&T had accepted that it was incapable of effectively bringing the technology to market. That acquisition transformed BEA into a business with annualized revenues in excess of $100 million by January 31, 1997, the end of its first full fiscal year, as it reached positive cash flow from operations. The success of Tuxedo enabled BEA to go public in April 1997, barely a year after the acquisition.

In its turn, a second decisive acquisition was contingent on that timely IPO. By 1998, the explosive growth of the internet as an environment for conducting commerce was visible to all interested parties. But none of the extant technologies had been designed to accommodate online electronic transactions with literally millions of simultaneous users. As BEA worked to augment Tuxedo to enable it to support ecommerce, a number of start-ups surfaced and almost as rapidly were acquired. Alfred Chuang, who was running BEA's engineering operations, identified one whose technology met his exacting standards, and he convinced Bill Coleman of the strategic value of the proposed acquisition.

The venture and its product were called WebLogic. As of September 1998, it had cumulative revenues of $500,000. As the bubble began to inflate with the promise of the economic transformation being wrought by the internet, so did the valuation of start-ups. WebLogic's asking price was no less than $150 million, or some 15 percent of BEA's then $1 billion market valuation, itself inflated by speculative fever. Had BEA not been able to use its own stock as the currency for the acquisition, it could not have happened.

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investment, see D. C. Mowery, "Military R&D and Innovation," in B. H. Hall and N. Rosenberg (eds.), *Handbook of the Economics of Innovation,* 2 vols. (Amsterdam: North-Holland, 2010), vol. II, pp. 1219–1256.

[25] The canonical text on the subject is C. Christiansen, *The Innovator's Dilemma: When New Technologies Cause Great Companies to Fail* (Cambridge, MA: Harvard University Press, 1997).

The acquisition of WebLogic represented a conscious decision to refuse to accept the terms of the innovator's dilemma and instead to attack our own core business before anyone else could. Tuxedo was a massive software platform whose installation and tuning took months of work by teams of highly trained engineers. It was typically sold as the core technology of a major project, a sales process that itself typically took many months. WebLogic incorporated the most advanced software engineering techniques to achieve rapid deployment and high performance; it could be readily scaled from single-user to very large application environments. BEA was now a trusted source of mission-critical software for the enterprise market. Word spread across the technical communities that WebLogic was the way to transform the internet into an effective and secure platform for commerce. The result was phenomenal growth: from $290 million in the fiscal year ended January 31, 1999, to almost $500 million the following year, and more than $800 million in the fiscal year ended January 31, 2001.

The conjuncture that linked BEA's growth as a business with the stock market's evaluation of the "new economy" made BEA one of the all-time great venture investments. **[SLIDE 13 HERE]** BEA's stock, having been split 2:1 in December 1999 and again in April 2000, reached an all-time peak of 85 during December 2000, or 320 on the shares originally issued to the public in April 1997 at 6. In August 1999, Warburg Pincus began to distribute its ownership: within sixteen months, our $54 million cash investment had been transformed into liquid, freely tradable shares with cumulative value at time of distribution of $6.5 billion.

The bubble of 1999–2000 revealed the financial dynamics of the downstream phase of the Innovation Economy at its most extreme. The host of hopeful monsters, the vast majority of which failed, could be funded precisely because those who provided the financing needed to have only minimal concern for the fundamental economic value of the ventures. The investment decisions, by the founding venture capitalists as by the willing IPO purchasers, were not informed by evaluation of the future cash flows of the projects. The decisions were driven by the hope, indeed, the expectation that well before any cash flows would be generated, the shares would be sold to yet more optimistic—or foolish—buyers.[26] Here too, as with upstream investments in scientific discovery and technological invention, the Innovation Economy turns on the ability of the economic system to tolerate waste. The systemic cost is less to the extent—as was largely the case in 1999–2000—that speculative excess is limited to the equity markets and does not spill over to infect the credit system on which routine economic activity relies.

Finance theorists have constructed a rich literature on bubbles. Much of it consists of formal models to demonstrate how the actions of rational investors can drive prices away from their "fundamental" – the discounted net present value of expected future cash flows – for example due to limits to arbitrage.[27] The relevance of much of this work is, however, compromised by a residual faith in that knowable "fundamental," privileging a certain set of investors with accurate expectations of the

[26] For a formal model of how overconfidence can drive a bubble, see J. Scheinkman and W. Xiong, "Overconfidence and Speculative Bubbles," *Journal of Political Economy,* 111, no. 6 (2003), pp. 1183-1220.
[27] A. Shleifer and R. Vishny, "The Limits of Arbitrage," *Journal of Finance,* 52, no. 1 (1997), pp. 32–55.

uncertain future.[28] It is missing the first reality of the equity markets. William Goldman, novelist and screenwriter, legendarily defined the law of Hollywood to be: "No one knows anything." The law of the equity markets is both softer and more complex: "No one knows enough, and everyone at some level knows that about herself and everyone else." **[SLIDE 14 HERE]** Frydman and Goldberg put it nicely:

> In the vast majority of cases, the prospects of investment projects—the stream of future returns—cannot be understood in standard probabilistic terms . . . This is obviously true for investments in innovative products and processes for which estimates of returns cannot be based solely on the profit history of existing products and processes.[29]

Even more deeply irrelevant, however, are market models that begin by supposing the existence of a rational, representative agent. In fact, the capital markets are populated by a diversity of human beings with widely varying beliefs and degrees of confidence in their beliefs about possible future outcomes. The markets, after all, were invented to enable participants with differing views to trade titles to assets with each other. And so the notion of a representative agent is incoherent, justifiable only by the fanciful belief that trading activity will costlessly converge to that fundamental value which, by hypothesis, the representative agent already knows.

The phenomenon that terminated the dotcom/telecom bubble in 2000 stands witness. **[SLIDE 15 HERE]** From the third quarter of 1999, the value of total distributions by venture capital funds to their limited partners rose from $3.9 billion to $10.7 billion in the fourth quarter of that year, then doubled again in the first quarter of 2000 to $21.1 billion. This was by far the largest realization by venture capital firms ever, before or since. At the same time, the ratio of stock distributions to cash distributions increased from 1.27 in the third quarter of 1999 to 2.91 in the fourth quarter of that year, then peaked at 3.93 in the first quarter of 2000. By distributing shares rather than selling them and distributing cash, the venture funds could mark the value of their realizations at the market price before the impact of incremental sales from the previously illiquid supply was felt.[30] Having been locked up, typically for six months, by the terms of their contracts with the underwriters of the IPOs, venture capitalists were finally free to allow their limited partners to sell, and sell they did. But note: this signal requires the existence of multiple traders in the market disagreeing with each other as to the relationship of price to value.

Since 2000, the exploration of bubble dynamics has broken out of the fetters of the rational expectations hypothesis to consider the behavior of agents whose expectations differ and who

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[28] Two canonical examples are: J. B. DeLong, A. Shleifer, L. Summers and R. Waldmann, "Noise Trader Risk in Financial Markets," *Journal of Political Economy,* 98, no. 4 (1990), pp. 703–738 and A. Shleifer and R. Vishny, "The Limits of Arbitrage," *Journal of Finance,* 52, no. 1 (1997), pp. 32–55.

[29] R. Frydman and M. Goldberg, *Beyond Mechanical Markets: Asset Price Swings, Risk, and the Role of the State* (Princeton University Press, 2011), pp. 41-2.

[30] McKenzie and Janeway, "Venture Capital and the IPO Market," p. 39.

themselves recognize the limits of their own and others' knowledge.[31] But it is not enough to contrast the new behavioral finance literature with the rational bubble literature. For in this term *rational* and in its antithesis there is a nexus of confusion that infects both academic and popular discussion of how economic and financial agents think and act. Much of this originated with the hijacking of the term by the theorists of REH. **[SLIDE 16 HERE]** As Frydman and Goldberg have written:

> A rational, profit-seeking individual understands that the world around her will change in non-routine ways. She simply cannot afford to believe that, contrary to her experience, she has found a "true" over-arching forecasting strategy, let alone that everyone else has found it as well.[32]

Confusion is also created when the deployment of heuristics—rules of thumb that help investors make decisions under uncertainty—is branded as irrational. During my own education in the craft of venture capital, I learned early and painfully and too often that the sole, conjoint hedge against the un-anticipatable onset of adversity – when "stuff happens" – is Cash and Control. That is, unequivocal access to enough cash to buy the time needed to evaluate what is happening, and enough control of events to change the terms of the problem. At the micro-scale of the venture capitalist, this means the power to force a sale of the project or to recapitalize it towards an amended goal (and usually begins by firing the CEO). But the imperative to hedge uncertainty can be read at grander scale: from J. P. Morgan's construction of a "fortress balance sheet" at the onset of the global financial crisis to China's accumulation of $3 trillion of reserves over the decade from the Asian Flu at the end of the last millennium. In every case it means holding "irrationally" large reserves of cash relative to what would be appropriate in the phantasy world of "complete and efficient markets."

Thus, Cassius was wrong. The fault is, indeed, in our stars. Born into a universe in which the Second Law of Thermodynamics holds and time's arrow moves in one direction only, we cannot run the equations backward. We spend half our lives arguing about the meaning of a past that we have actually experienced, and the other half speculating about an infinite array of alternative futures. In this context, attributing market inefficiency to the irrationality of investors is fundamentally mis-focused. Rather, let us say that by and large they—we—do the best we can.

In parallel with the maturation of the bubble literature within finance theory, attention is finally being drawn to why bubbles matter to the real economy. They matter because not only do they transfer wealth from greater to less great fools and to the knaves who prey on the former. Occasionally—as with BEA—they transfer wealth to fortunate opportunists and insightful entrepreneurs in the market economy,

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[31] See, for example, H. Hong and J. C. Stein, "Disagreement and the Stock Market." *Journal of Economic Perspectives*, 2007 21(2): 109–128.

[32] R. Frydman and M. Goldberg, "The Imperfect Knowledge Imperative in Modern Macroeconomics and Finance Theory," in R. Frydman and E. Phelps (eds.), *Micro-Macro: Back to the Foundations* (Princeton University Press, in press), p. 27.

who are granted access to cash on favorable terms and put it to work with astounding consequences. **[SLIDE 17 HERE]** As usual, Keynes got there first:

> The daily revaluations of the Stock Exchange . . . inevitably exert a decisive influence on the rate of current investment. For there is no sense in building a new enterprise at a cost greater than that at which a similar existing enterprise can be purchased; while there is an inducement to spend on a new project what may seem an extravagant sum, if it can be floated off on the Stock Exchange at an immediate profit. Thus certain classes of investment are governed by the average expectation of those who deal on the Stock Exchange as revealed in the price of shares, rather than by the genuine expectation of the professional entrepreneur.[33]

In this spirit, one recent theoretical exercise models the game played between entrepreneurs and speculators, as each seeks to evaluate the potential return to innovation, thereby generating positive feedback between the prices of financial assets and the volume of investment in the corresponding innovative technology.[34] **[SLIDE 18 HERE]** A relevant empirical investigation estimates the extent to which the dotcom/telecom bubble enabled huge increases in R&D spending by young firms.[35] This is promising work and deserves sponsorship and encouragement.

As the history of BEA confirmed, the role of speculative excess complements the role of the state. Of course, economists have long recognized that market failure legitimizes state intervention…in theory.[36] And the market's failure to allocate sufficient resources to scientific discovery and technological invention is often cited as a prime example.[37] Yet as an effective rationale for state intervention, market failure has proved inadequate.[38] Instead, causes that transcend economic calculation—national development, national security, conquest of disease—have been required. And so, upstream and downstream, the dynamics of the Innovation Economy challenge the philosophical core of neoclassical economics. For the evolution of the Innovation Economy through historical time resists reduction to the optimal inter-temporal

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[33] J. M. Keynes, *The General Theory of Employment, Interest and Money,* in E. Johnson and D. Moggridge (eds.), *The Collected Writings of John Maynard Keynes*, vol. VII (Cambridge University Press and Macmillan for the Royal Economic Society, 1976 [1936]), p. 151.

[34] G.-M. Angeletos, G. Lorenzoni and A. Pavan, "Beauty Contests and Irrational Exuberances: A Neoclassical Approach," National Bureau of Economic Research Working Paper 15883 (2010).

[35] J. R. Brown, S. M. Fazzari and B. C. Petersen, "Financing Innovation and Growth: Cash Flow, External Equity, and the 1990s R&D Boom," *Journal of Finance,* 64, no. 1 (2009).

[36] W. J. Baumol, *Welfare Economics and the Theory of the State*, 2nd ed. (Cambridge, MA: Harvard University Press, 1969), and A. C. Pigou, *The Economics of Welfare,* 2 vols. (New York: Cosimo Classics, 2010 [1920]).

[37] The foundation texts are: R. R. Nelson, "The Simple Economics of Basic Scientific Research," *Journal of Political Economy,* 67 (1959), pp. 297–306, and K. Arrow, "Economic Welfare and the Allocation of Resources for R&D," in K. Arrow (ed.), *Essays in the Theory of Risk-Bearing* (New York: American Elsevier, 1971 [1962]), pp. 144–163.

[38] Two stimulating attacks on the limits of the "market failure" literature bracketed the largest such instance since 1933: J. Kay, "The Failure of Market Failure," *Prospect*, no. 137, August 1, 2007 and W. Hutton and P. Schneider, "The Failure of Market Failure: Towards a 21st Century Keynesianism," National Endowment for Science, Technology and the Arts, Provocation 08 (November 2008).

allocation of resources.[39] Yet, in the face of historical experience, persistent and excessive devotion to the principles of neoclassical economics has consequences.

Those who hold the state to rigorous criteria of efficiency in the allocation of resources not only inhibit toleration of the "Schumpeterian waste" inherent in the operation of the Innovation Economy. They also encourage toleration of the deadweight loss that is represented by unemployed resources of human labor and physical capital—what, in recognition of Keynes's valiant assault on the phenomenon, I call "Keynesian waste." During the 1930s, Keynes sought to establish a new macroeconomic rationale for responsive state intervention independent of the specific projects it financed. **[SLIDE 19 HERE]** He began with the recognition that the marginal productivity of unused resources is negative as skills atrophy and machines rust. Any vehicle that sponsors incremental consumption by providing employment of whatever sort would be a less bad alternative: even stuffing old bottles with pound notes and burying them under mountains of municipal waste! Keynes failed in this project, as he ruefully recognized. **[SLIDE 20 HERE]** When full employment did return, it was the result of the most economically wasteful of all imaginable state investments, mobilization for total war.

Today, 75 years on, the same argument that blocked civilian investment by the state has been effectively re-mobilized: definitionally wasteful, debt-financed state expenditures will undermine the confidence of businessmen and investors alike. The oxymoronic pursuit of "expansionary fiscal austerity" serves both to rationalize the toleration of Keynesian waste and to limit the toleration of Schumpeterian waste. The double-edged impact is compounded by the interaction between the two effects. When Keynesian waste is at a minimum—that is, in a high-growth, fully employed economy—the consequences of Schumpeterian waste are likely to be more creative and less destructive. More innovations will be profitably exploited, and the people and capital stranded in legacy occupations will be more rapidly redeployed. And very much vice versa.[40]

Although Keynesian waste today is at a markedly lower level than characterized the Great Depression, the rich nations of the world seemed determined to reenact that greatest of historic failures of economic and financial policy. Forces have been at work for a generation to delegitimize the state as an economic actor. To the extent their success persists, in the near term we will forgo growth, employment and income. In the long term we will witness the west's leadership of the Innovation Economy pass, even as the next new economy can already be defined in broad strokes.

Like the digital one we are currently still learning how to explore and enjoy, that low-carbon economy can be built only on a base of substantial state investment and agreed rules of engagement across both public and private sectors. To advance the frontier of needed innovation, much science

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[39] For relevant alternative approach that takes both time and uncertainty seriously, as discussed in chapter 12, see R. R. Nelson and S. G. Winter, *An Evolutionary Theory of Economic Change* (Cambridge, MA: Belknap, 1982).

[40] For exploration of the feedback effect, see: J. Stiglitz, "Endogenous Growth and Cycles," in Y. Shionnoya and M. Perlman (eds.), *Innovation in Technology, Industries and Institutions: Studies in Schumpeterian Perspectives* (Ann Arbor, MI: University of Michigan Press, 1994); G. Dosi, G. Fagiolo, and A. Roventini, "Schumpeter Meeting Keynes: A Policy-Friendly Model of Endogenous Growth and Business Cycles," *Journal of Economic Dynamics and Growth,* 34 (2010) and J. B. Delong and L. H. Summers, "Fiscal Policy in a Depressed Economy," (Brookings, 2012).

remains to be done. A host of technologies—batteries and solar cells and fuel cells, among them—require extended investment to improve both absolute performance and the ratio of performance to cost. And the protocols for bringing alternative, renewable energy sources online and into the intelligent grid that is yet to be designed, let alone deployed, will need to be standardized, as were the networking and inter-networking protocols of the digital economy.[41]

However, no significant private-sector investment in the new infrastructure, let alone the speculative funding necessary to finance deployment at scale, can be expected while the return on that investment remains exposed to the volatile markets of conventional energy sources. Only collective state action—the prospect for which is not at all visible—can enable the new alternative energy technologies to compete with conventional sources without state subsidy. In parallel, advances in materials to reduce the carbon content of consumer goods and services are similarly required and at risk. As in the development of the digital economy, state procurement programs open to all will prove more effective than selective state subsidies to would-be winners.

Even while we are forced to wait in frustration for the next new economy, there is work for the practitioner in completing the rollout of this one. There is also much work for the theorist. I did not expect to live to see the economics I had absorbed at Cambridge more than forty years ago—the economics of Keynes; of uncertainty at the level of the individual and of consequent instability at the level of the integrated financial economy—again become so relevant and so broadly recognized as such within the discipline.

The intellectual entrepreneurs who have accepted the challenge to reconstruct financial economics are largely motivated by recognition that markets are not the mechanical, self-regulating artifacts of neoclassical theory. And so the state may be let back in at the macroeconomic level after current exercises in austerity have failed to generate renewed economic growth.[42] But the reconstruction of financial economics will remain incomplete so long as its scope excludes a positive role for the state in the Three-Player Game of innovation. The intellectual framework that relates how Schumpeterian waste can be productively sponsored by the state is as urgently required as theories that subvert the toleration of Keynesian waste.

END

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[41] For one of many frustrated calls to action, see Bill Gates's guest editorial in *Science:* "The Energy Research Imperative," *Science,* 334 (2011), p. 877.

[42] The prime text for understanding "big-state capitalism" remains, twenty-five years after its publication, H. P. Minsky, *Stabilizing an Unstable Economy* (New Haven, CT: Yale University Press, 1986).

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