

CAPITAL AND CREATIVE DESTRUCTION:

Venture Capital, Technological Change, and Economic Development

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INTRODUCTION

Ever since the transition from feudalism to capitalism, and perhaps even before, the rise of new technologies, new ways of producing goods, and of whole new industries has required capital and credit, or what is more commonly referred to as venture capital. Throughout this industrial history, it has been more common than not for such capital to be mobilized by new providers rather than established institutions of finance. The role of these new institutions of venture finance has been to overcome the risks and other barriers associated with more traditional financial institutions and make the required investments in those new innovations and business opportunities which are the engines of technological change and economic growth. While at times traditional financial institutions have supplied the ultimate source of capital for these opportunities, the role of these new financiers of innovation has been to mobilize capital from these and other sources and to provide it to those entrepreneurs and risk-takers that have provided much of the impetus for technological progress and economic development.

The classical economists from Adam Smith to Karl Marx outlined the broad relationship between capital and industrial development. But, perhaps the clearest statement of capital's role in the processes of innovation and economic development was provided in Schumpeter's classic work, *The Theory of Economic Development*.¹ In Schumpeter's view, capitalism is an inherently dynamic economic and social system; the source of such dynamism lies in the process of innovation. Powering the process of economic development is the phenomenon Schumpeter referred to as *creative destruction*, which "incessantly revolutionizes

the economic structure *from within*, incessantly destroying the old one, incessantly creating a new one."² The linchpin of this process, Schumpeter observed, was the entrepreneur, whose function is to "carry out new combinations" of products, markets, supplies, raw materials, and business organizations required for technological innovation and economic growth.

Schumpeter further noted that new financial forms at times emerge to assume the risk and uncertainty associated with technological innovations and the rise of new entrepreneurial firms and industries. He emphasized the role of new financiers in supporting entrepreneurs in their quest to carry out these new combinations in the process of creative destruction.³ For Schumpeter, the provision of capital and credit to entrepreneurs is a vital element of a dynamic capitalist economy, indeed, "important enough to serve as its *differentia specifica*."⁴

For neoclassical economic theory, the provision of capital and credit is viewed as highly mobile with adjustments occurring relatively quickly over time and space. In Joseph Stiglitz' seminal formulation, capital markets allocate scarce capital among competing users and provide signals to managers making investment decisions.⁵ Many leading economic historians, however, suggest that industrial development is punctuated by periods of market imperfection, or what Lance Davis has referred to as the "immobility of capital."⁶ Economic geographers too see finance as characterized by market imperfections and geographic differences which constrain and orient capital flows to particular places.⁷ Here, especially, Schumpeter's entrepreneurs provide agency where established institutions of capital fail to pursue opportunity.

Clearly, the field of business and economic history has provided a deep and thorough

understanding of the role of new enterprise formations and technological change in American economic history. However, there is surprisingly little systematic research on role and relationship of financial institutions to technological innovation, and economic growth.⁸

In this essay, we focus on the role played by venture capital in the processes of technological innovation, new business formation, and economic development. Venture finance differs from more traditional financial intermediaries in two rather fundamental respects. One, venture capitalists exchange equity for an ownership stake instead of providing more traditional forms of debt or fixed income securities which require collateral and a regular repayment schedule. Two, venture capitalists are actively involved in the strategic development and management of the enterprises in which they invest; they are more concerned with growing the business' cash flows.

In our view, new forms of venture finance are typically required to finance the birth of new technologies and business organizations, and the more general process of technological and industrial development.⁹ Thus, the rise of new forms of finance, or venture capital, correspond to the rise of new industries, e.g., textiles, primary metals, semiconductors, biotechnology, and now the so-called multi-media "telecosm" defined by the intersection of entertainment, computing and telecommunications.¹⁰

We focus explicitly on the role of new forms of venture finance in the various industrial transformations in American economic history.¹¹ We organize our discussion around the intersection of venture finance and industrial development in particular industrial regions. First, we begin our analysis with the role of early and rather rudimentary forms of venture

finance in the growth and development of the textile complex in and around Boston or what historians such as Lance Davis, Robert Dalzell, and Naomi Lamoreaux have referred to as relationship banking or equity-financed "insider lending." Second, we then turn to the role of a new group of venture financiers in the rise of the science-based and/or mass-production industries of the late 19th and early 20th centuries. Drawing from original archival research, we focus on the venture capital activities of the Mellon interests in organizing the technology-based industries, particularly in the materials and chemical sectors, in and around Pittsburgh.¹²

Third, we explore the rise of an integrated and increasingly institutionalized venture capital industry to finance the new high-technology industries of semiconductors, computers, and biotechnology in California's Silicon Valley and the Route 128 area surrounding Boston.¹³ In doing so, we draw from extensive primary research and persona interviews conducted with venture capitalists in these two regions.¹⁴ This increasingly formal, organized and institutionalized system of venture capitalists exchange capital for an equity or ownership stake, participate actively in the development and management of the enterprises in which they invest, and invest in informally organized syndicates, combining the activities of financier, manager, and entrepreneur.¹⁵ Furthermore, this modern brand of venture capital has organized into a formal industry with its own associations (e.g. the National Association of Venture Capitalists), its own research organizations (e.g. Venture Economics and Venture One), and trade publications (e.g. *Venture Capital Journal*).¹⁶

Early Venture Finance and the Rise of New England Textiles

The textile industry, as many have noted, propelled the process of American industrialization. Centered around Boston and Lowell this industry provided the foundation for subsequent industrial growth and economic development, and according to Brook Hindle and Stephen Lubar, "set the style of American mechanization, industrialization, and work."¹⁷ The factory system accelerated the shift from piece-work to mechanized production transforming the workplace in fundamental ways. Beyond this, the growth of textiles elicited changes in the structure of industrial financing. With innovative developments in machinery, factory organization, and production, the textile industry required massive amounts of capital; but where would that capital come from? As many scholars of the New England industrial experience have pointed out, the cotton textile industry was one of the first industries organized with the aid of external capital, garnered in large part from the newly formed Boston Stock Exchange in the early 1820s. Merchants and banking institutions supplied the initial source of financing for the rise of textile industry's factory system, and as the requirements for more capital outstripped the ability of banks and merchants to supply it, many merchant houses reinvented themselves as manufacturing capitalists, with ties to their established trading networks, the new stock exchange, banks, and their own sources of private capital. Out of this melange of financing mechanisms emerged a credit market for Boston's burgeoning manufacturing enterprises.

A primary reason for Boston's rise to manufacturing excellence between 1815 and 1860 was the inventiveness of Francis Cabot Lowell, founder of the Boston Manufacturing Company, a pioneer in the textile industry of New England. The company represented the

first successful implementation of the British proprietary technology known as power looms, implementing it on a scale unheard of in existing British or American mills.¹⁸ This required not only innovative approaches to management and organization; it also taxed the conventional methods of entrepreneurship.

Such a high level of capitalization was, according to Lowell, required to adequately equip the factory and provide a safe margin to cover operating expenses. Although capitalized at nearly ten times the amount of competing mills, Lowell and his associates at the Boston Manufacturing Co. kept tight reins on the management of the enterprise.¹⁹ In fact, only seven stockholders controlled the entire capital stock of the company. This was rather significant, particularly as increasing scale tended to require new forms of organizational management and control. The Boston Manufacturing Company obtained its capital through an enormous subscription to the company's capital stock by a small group of local investors. The company authorized \$400,000 of capital stock, which was issued in three subscriptions. The price was \$1,000 per share, which most investors paid in installments over five years.²⁰ Boston Manufacturing Co. became a model for the financing of manufacturing concerns. Furthermore, it enabled traditional mercantile capitalists to invest in new industrial opportunities promising previously unparalleled rates of return.²¹

The explosive growth in stock subscriptions to local manufacturing mills was facilitated by close-knit relationships between up-start manufacturers and bankers. Naomi Lamoreaux has argued that "insider lending" played a fundamental role in the industrial development of Boston and the New England region more broadly. According to Lamoreaux, as banks formed

in towns and communities throughout the region, they provided more than basic savings and loan functions, figuring in economic development. In a role somewhat similar to that of venture capitalists, banks provided funds to their directors who in turn funneled those funds into manufacturing enterprises. This process of insider lending overcame constraints in the financial markets, providing a much-needed spur to entrepreneurial enterprise. As Lamoreaux points out, "whenever banks maintain an arms-length relationship with their customers, they tend to avoid the risks involved in financing entrepreneurial ventures."²² The rise of New England's textile industry benefited from close association between bankers and industrialists, enabling capital to be channeled to nascent enterprises.

Rigidities nonetheless began to emerge in this new system of industrial finance. Before 1860, sales-generated equity or retained earnings was the most important source of capital for industrial expansion.²³ As Cochran notes, "Problems regarding the entrepreneur in capital formation do not differ greatly from those in general economic growth....In the early phase of industrialization most initial financing was of local origin and there was an intimate relation between entrepreneurs and investors. Expansion of the business was usually financed by reinvesting profits".²⁴ However, the relative importance of equity waned over time. Lance Davis, perhaps the foremost economic historian of capital formation in American industry, argues that American economic and industrial development was punctuated by periods of capital shortage and inflexibility, or what he terms "capital immobility." Davis suggests that capital immobility became acute in the post-bellum decades because capitalist firms required external finance (or access to greater resources) as a result of industry's westward migration,

and technological innovations in manufacturing ushered in by mass production. While New England's textile industry gave rise to the most advanced capital markets in the nation, little of that capital moved to the South despite the South's intricate involvement in the existence of a textile industry in Boston. Impeded by communications and transportation systems ill-equipped to handle continental transactions, New England lenders could not efficiently tap into potential frontier markets, although they actively attempted to establish financial ties to the frontier.²⁵ Southern and Western industry experienced a widespread shortage of capital, and local pooling of capital was necessary to help these industries finance their expansion. The inflexibility of financial markets comprised a major obstacle to industrial expansion for much of the later 19th century.²⁶

The role of venture finance in the early textile industry eventually became less important. Gradually, more modern forms of finance began to replace the older, more personal mechanisms. The mobilization of capital through more organized investment and financial markets provided the alternative to self-financed growth and the kind of insider lending Lamoreaux identifies. By the late 19th century, new stock and bond markets were beginning to develop outside of traditional financial centers on the East coast, and during the 1890s long-term sources of capital from banks, trust companies, and life insurance companies began to channel funds into industrial markets.²⁷

But, as we will see, the rise of new, technologically advanced industries would continue to rely on local pooling and the emergence of new regional sources of venture capital similar in many respects to those associated with the growth and development of the textile industry in

New England. As the next section will show, the rise of the new science-based industries of the late 19th and 20th century would require new forms of venture finance which shared a number of characteristics with those identified immediately above. England.

Financing the Second Industrial Revolution:

Andrew Mellon and the Pittsburgh Technology Complex

The new form of industrial organization, which most clearly reflected the need for new financial mechanisms, was the modern science-based industrial enterprise. Although eastern capitalists located in colonial centers of merchant finance like New York, Boston, and Philadelphia, were by and large the dominant source of new venture capital, the emerging industrial complexes of Western Pennsylvania and the Great Lakes region gave rise to their own financial centers. The growth of the modern, *M-form* corporation and the broader economy that it helped to shape and which in turn supported the corporation, are now fairly well understood. Chandler has termed this the managerial revolution and has highlighted the importance of communications and new markets.²⁸ The modern corporation became a propulsive force in the American economy and could not have done so without new forms of finance feeding its insatiable appetite for capital.

Today, we clearly understand the impact of the M-form corporation and mass production on American society. Less well understood, however, is the symbiosis between new forms of finance that emerged to organize this nascent and dynamic industrial system. The second industrial revolution, like the first, required the development of a series of new

financial forms and mechanisms to provide the capital and credit required for technological innovation and industrial expansion. Older, more traditional financial forms were in most cases far too risk averse to undertake the required investments. Indeed, impeding the emergence of this new technology-intensive industrial system were a series of rigidities or temporary failures in the financial markets.²⁹ Throughout the nineteenth century, capital remained a major obstacle to industrial development, as the pace and demand for investment outstripped the ability of lenders to provide it.³⁰

Clearly, one of the most important financial innovations of this period was the rise of investment banking activity. As Vincent Carosso's landmark study *Investment Banking in America* outlines, the direct personal ties of the early to mid-19th century became increasingly institutionalized. The railroads, a harbinger of the new corporate form, also best exemplified the growing popularity of securities and bond offerings during the 1870s and 1880s as a form of finance. As Carosso notes, "Bank representation on railroad directorates...was an institutionalization of the close personal ties that commonly had existed between bankers and railroad officials."³¹ The structure that emerged to serve the capital needs of the railroad industry provided a model for industrial firms to follow. The new investment banking syndicates emerged because the immense size of industrial capitalization prevented any one firm from bearing the burden of underwriting corporate financing.³²

Venture capital was also important to the rise of new science-based industries. As we will see, venture capital would play a central role in the growth and development of an advanced and integrated complex of technology-based industries during the latter part of the

19th century. There were two differences between the early and rudimentary forms of venture finance associated with New England textiles and the venture finance of the second industrial revolution. Both of these were evolutionary in nature. First, it required far larger sums of capital to finance the advanced technologies and immense plant and equipment associated with the science-based industries such as electrical power, materials and chemicals. Second, the venture capitalists of the second industrial revolution played a more central or nodal role in organizing technological capabilities, pulling together business capabilities, and in building the broader infrastructure from which individual enterprises would draw. These venture capitalists thus took on a rather extensive set of non-financial activities - or more appropriately extra-financial activities - in managing the birth and development of new enterprises and industries. They thus evolved the functions of technological gate-keeping, networking, and non-financial resource mobilization associated with modern-day venture capital.

The technological-industrial complex of the greater Pittsburgh region provide a good window from which to illuminate the evolution of these venture capital activities and functions. Pittsburgh was a center for industrial innovation in the materials, electrical power and chemical industries, and developed as an integrated technological complex. As with American industry more broadly, Pittsburgh industry faced difficulty mobilizing capital during the mid-to-late 19th century. A common practice in the region time was for fledgling entrepreneurs to approach established industrial enterprises who had built up vast equity which could become a source of lending capital. This gave rise to a new form of venture finance, which fuelled the development of the region's increasingly diversified manufacturing complex. Andrew

Carnegie's venture into steelmaking, for example, was funded through equity gained in partnerships with established iron producing families of Phipps, Kloman, and Shinn, and not coincidentally through his success at the Pennsylvania Railroad. Similarly, George Westinghouse's air brake concern received financial backing from Robert Pitcairn, a Pennsylvania Railroad Vice President, and brother of John Pitcairn who later teamed with John Ford to launch the Pittsburgh Plate Glass Company. Initial backing for H. J. Heinz's 1869 founding was provided by L. Noble, a successful brick manufacturer. That same year, Henry Frick obtained start-up capital for his eponymous coke works from the A.O. Overholt Co. distillery.

But, it is the venture finance activities of the Mellon interests, which best illustrate the emerging functions of venture capital during this period. Indeed, the Mellon interests activities mirror those of contemporary venture capitalists in many respects, by providing both financial resources and management assistance in helping to organize and incubate new industrial enterprises and an entire regional complex of industrial enterprises.

Andrew Mellon's first foray into venture finance involved underwriting Henry Clay Frick's coke business in 1871. In 1874, despite a severe depression in Pittsburgh, T. Mellon & Sons provided H.C. Frick Coal & Coke Co. with a \$15,000 loan, a \$25,000 line of credit, and assumed a \$76,000 mortgage on some coal property.³³ The first of Mellon's venture investments, Frick was anomalous, and in some sense could be considered a learning experience. It was the only investment in which Mellon did not stipulate significant equity participation and managerial control, a practice that would distinguish Mellon-style venture

capital from that point on.

The case of the aluminum industry clearly illustrates Mellon-style venture capital. Discouraged by the cool reception to his aluminum reduction process at Cowles Electric Smelting & Aluminum Co., in July 1888 Charles Martin Hall came to Pittsburgh to demonstrate his patented electrolytic process for reducing pure aluminum by dissolving alumina in molten cryolite.³⁴ A company was organized on August 8th of that year by Captain Alfred Hunt and George Clapp of the Pittsburgh Testing Laboratories, and a small shop was established.³⁵ When Hunt and Charles Martin Hall approached Andrew Mellon for \$20,000 expansion loan, Mellon offered \$1 million in venture capital in exchange for a 40 percent equity participation in the new firm.³⁶ Importantly, Mellon insisted upon naming his own general manager, Arthur Vining Davis, in return for the investment. This case thus represents a critical point in the evolution of Mellon's involvement in venture capital - the exchange of capital for equity and an ownership stake, and an active hand in the organization and management of the new enterprise.³⁷

Mellon's growing interest in venture finance convinced him that he needed a formal organization to effectively make venture investments. The vehicle he devised was the Union Trust Company organized in 1889.³⁸ After floundering between 1889 and 1895, Union Trust began to aggressively pursue equity investments and syndicated lending to start-up manufacturers. Over the next two decades, Mellon amassed an impressive array of manufacturing investments, ranging from oil exploration and aluminum production to structural steel manufacturing and railroad car companies.³⁹ Nearly a dozen new enterprises,

mergers and acquisitions were orchestrated by Union Trust Co. which underwrote and marketed corporate securities such as stocks and first mortgage bonds, including: McClintic Marshall (1899), Mon River Coal & Coke Co. (1899), Pittsburgh Coal Co. (1899), Union Steel Co. (1899), Standard Steel Car Co. (1902), Carborundum Co. (1895), Crucible Steel Co. of America (1900), Pittsburgh Steel Co. (1901), and Gulf Refining Co. (1903). Additionally, Mellon reorganized the T. Mellon & Sons bank, acquiring the City Deposit Bank, Pittsburgh National Bank of Commerce, and the Citizens National Bank and rolling them up into one colossal institution, the Mellon National Bank, N.A. in 1902.

Mellon later invested to relocate by-product coking industry of the Heinrich Koppers Company to Pittsburgh from Joliet, Illinois.⁴⁰ And, of course, Mellon made considerable forays into the steel industry. In a matter of three years, Mellon organized three conglomerates to compete directly in markets that Carnegie's steel empire dominated.⁴¹ The icing on the cake was the sale of Union Steel, in which Mellon had personally invested \$100,000, to the U.S. Steel Corporation in 1903 for nearly 300 times that amount.⁴²

In his quest to build an integrated complex of finance, manufacturing, and cutting-edge innovation, Mellon sought to create a central source of technological innovation for the firms in which he had invested. In 1909, he read an account of an Applied Chemistry laboratory at the University of Kansas, and spent the next two years convincing the founder, Robert Kennedy Duncan, to relocate in Pittsburgh. Duncan's book, *The Chemistry of Commerce*, outlined the financial rewards that could be realized by marrying scientific research and development and commercial manufacturing. In 1913, the Mellon Institute of Industrial

Research was established as a center for metallurgical and chemical research done in collaboration with Mellon's local industrial holdings. In his regard, Mellon style venture capital sought to build a technological infrastructure off which entrepreneurial ventures could draw.

Our case study of the Mellon interests provides an important window into the relationship between venture capital and industrial development in the late 19th and early 20th centuries. The venture capital and financial activities of the Mellon interests exemplifies the concomitant rise of new forms of finance and new industrial enterprises. Mellon's style of venture investing involved a combination of innovative forms of finance and direct managerial control. Furthermore, Mellon's strategy for venture investing reflected a keen sense of the advantages of technological and industrial infrastructure, or what geographers refer to as agglomeration, and the propulsive effect of an integrated industrial complexes.⁴³

Venture Capital and the High-Technology Revolution

The origins of what is now thought of as the modern, institutional venture capital industry date back at the Great Depression and the World War II period.⁴⁴ Despite the immediate financial and economic problems of the Depression, the 1930s saw the origin of a proto-venture capital industry organized by a small group of financial elites such as Jock Whitney and Laurence Rockefeller who created small risk-capital funds. Whitney's own

contribution was nearly \$10 million, and Rockefeller's venture capital partnership placed roughly \$9 million in new ventures.⁴⁵ In fact, the phrase "venture capital" was coined at the 1939 convention of the Investment Bankers Association of America, where in his presidential address, Jean Witter, highlighted the need for new forms of venture capital to spur economic growth and revitalization.

During this period, it was believed the financial reform and restructuring associated with the New Deal system of financial regulation had led to specialization and segmentation of the U.S. financial system, focused almost exclusively on the needs of large, established industry. Indeed, smaller, start-up enterprises found the investment community rather unreceptive to their needs, in part because debt replaced equity financing and also as formal institutional procedures replaced more personalized forms of finance.⁴⁶

An important impetus for the modern venture capital system came from a group of influential bankers and industrialists who began to sketch out plans for a new government agency devoted to the problems of small business and small business finance. To lend legitimacy to their designs, they organized their efforts through the influential Committee for Economic Development (CED), a group concerned with the post-war planning and reconversion effort. Many of these elites were concerned with the increasingly conservative outlook of large corporations, and what Schumpeter referred to in his influential book of the period, *Capitalism, Socialism, and Democracy*, as the increasing bureaucratization of the innovation process. Many also believed that new mechanisms would be required to re-create the entrepreneurial impulse in the American economy - to nurture and support inventive new

enterprises.

While the push to develop new sources of capital for entrepreneurial endeavors proceeded on many fronts, the first and perhaps foremost of these efforts involved establishing a new federal program to support small business and provide small business finance. In 1945, Ralph Flanders published an influential manifesto on the subject, "The Problem of Development Capital," which made the case for the creation of new institutional structures to provide capital for innovative, entrepreneurial enterprises.⁴⁷ In 1947, a CED study outlined the need for policy initiatives to address the problem of adequate capital for the small business community.⁴⁸ Five years later, in 1952, *Dun's Review* asked "Can Small Businesses Get the Capital They Need?," concluding that capital markets were failing to provide required capital to entrepreneurial enterprises.⁴⁹ Furthermore, the study showed that small businesses faced interrelated managerial *and* capital crises, and that both must be addressed.

By the early 1950s, business and financial leaders were beginning to make the case for some sort of government program to bolster small business start-ups. The efforts of bankers and industrialists and the Committee for Economic Development led to the establishment of a new federal agency for small business development, the Small Business Administration. The CED's position was outlined in a series of studies and reports that provided much of the background for the establishment of the Small Business Administration.⁵⁰ And, by the close of that decade, they succeeded in getting the federal government to initiate a new program to create and to subsidize a new set of institutions, small business investment companies or SBICs, designed to provide finance capital to startup companies. In 1958, the Small Business

Administration was authorized to establish Small Business Investment Corporations (SBICs), which were private investment companies whose capital was leveraged against asset sources in the federal government. Many of the first venture capital funds actually emerged as SBICs. SBICs also benefited from mandated tax breaks and other investment incentives, which eventually enabled them to become an import source of venture capital, especially in new growth regions such as California and Massachusetts.

Both the federally sponsored SBICs and private investors saw a connection between the new emphasis on scientific research and commercial viability in the marketplace and sought to capitalize on it. Part of the solution was to forge closer links between entrepreneurship and scientific research and development. Vannevar Bush and others had effectively made the case for the importance of basic research in the war effort, and proposed to tap into the university as a source of new and potentially lucrative technologies. MIT led the way in the commercialization of academic research.⁵¹ Led by Vannevar Bush, Karl Compton, and Horace Ford, MIT envisioned turning the greater Boston region into an incubator of technology-based economic development. Ironically, they looked to the example of the Mellon Institute in Pittsburgh, sponsored by Andrew Mellon for his industrial investments, as the model of a regional focal point for industrially sponsored research and development projects. To realize this vision, Compton joined forces with a private development agency, the New England Council, to address the decline of New England industries, such as machine tools by providing capital and managerial support.⁵²

Immediately after the war, this group of Boston industrialists and bankers established

up a formal venture capital vehicle devoted to financing high technology enterprise -American Research and Development (ARD), the nation's first institutional venture capital firm.⁵³ They selected Georges Doriot, a Professor of Business at Harvard and former army general, to head their new institution. Although ARD failed to meet its initial subscription goal of \$5 million, it played a critical role in the emergence of the region's high-technology complex, providing the initial capital for Digital Equipment Corporation.

The structures of the modern venture capital industry came more fully into form with the rise of the new high technology industries of the post-World War II period. Most of the early professional venture capital funds were located in large financial centers such as New York, Chicago, and Boston. These funds were tied to either to wealthy families or later to large banks and financial institutions. The New York venture capital complex emerged during the Great Depression. Its catalysts were venture capital funds linked to family fortunes, most notably the Rockefellers (Venrock), Whitneys (Jock Whitney and Company), and Phipps (Bessemer Securities). The Rockefeller family made important venture investments in McDonnell Douglas and Eastern Airlines during the late 1930s, while J.H. Whitney and Co. provided backing for Minute Maid.⁵⁴ The Rockefeller family, for example, transformed its family-run venture interests into a formal venture capital firm, Venrock during the 1960s. It later provided early stage financing for a host of important high technology companies such as Intel and Apple Computer.⁵⁵ Other wealthy families did the same. Being close to large financial institutions, venture capital in New York grew very rapidly giving rise to some 50 New York funds tied to banks or investment houses and another 40 or so, linked to financial

institutions such as large commercial and investment banks.⁵⁶ During the 1960s and 1970s, New York City was the nation's largest center of venture capital. New York venture capitalists tended to invest their funds on a national basis, funnelling their capital to the burgeoning high-technology industries of Silicon Valley and the Boston Route 128 area.

Chicago was another important source of venture capital for high technology. Allstate Insurance was very important to the rise of Chicago venture capital. In 1960, it became one of the first financial institutions to set up a venture capital fund.⁵⁷ Allstate's director, Ned Heizer, made very successful investments in young high tech companies such as Control Data, Memorex, Scientific Data Systems, Teledyne, and others.⁵⁸ In 1969, Heizer spun off from Allstate and formed what was then the largest venture capital fund in the country, Heizer Corporation. Heizer Corporation became a training ground for venture capitalists and was in turn responsible for spinning off a number of important venture capital funds. Chicago banks became active in venture capital during the late 1960s and early 1970s with the First National Bank of Chicago spawning two venture capital affiliates and Continental Illinois also creating two venture capital units.

The modern institutional system of venture capital emerged during the 1970s and 1980s. During this period, the amount of funds devoted to venture capital skyrocketed from an average of \$3.5 billion to more than \$30 billion. There were four basic reasons for massive expansion in the amount of venture capital and more importantly for the institutionalization of that segment of the financial markets. First, sharp declines in the overall rate of profit during the mid-1960s prompted an investment shift from basic industry toward new industries and

more speculative investment opportunities. As a result, some small portion of the leftover capital from declining investment in old line industries, spilled-over into venture capital-related activities. Second, by the mid-1970s, it became obvious that venture capital investments produced huge returns far exceeding those on corporate stocks and bonds. This exerted a powerful pull on outside capital sources, drawing external capital into venture investments. Third, success itself was reinforcing, encouraging more entrepreneurs to form companies and opening up additional investment opportunities for venture capitalists. Fourth, two major changes in federal government policy, a series of reductions in the capital gains tax rate and the loosening of restrictions governing pension fund investments increased the attractiveness of venture capital and caused a variety of institutions to increase their venture capital investments.

Perhaps most significantly, it was only during the 1960s and 1970s that a new form of venture capital institution, the venture capital limited partnership, emerged to finance high technology companies. Under this new form, professional venture capitalists (the general partners of the fund) were able to raise money from limited partners, i.e., banks, corporations, pension funds, and wealthy families. Venture capital funds could now be established right in the heart of emerging technology centers by personnel familiar with the most current technologies and business opportunities. During the period stretching from the mid-1960s through the 1980s, a huge number of limited partnerships were formed.

The venture capital industry in Silicon Valley, which represents the largest concentration of venture capital in the U.S., emerged during the 1960s and 1970s alongside the

development of high-technology enterprises in that region.⁵⁹ Before then, entrepreneurs had to rely on industrial corporations or financial firms in more established financial centers for early stage funding. For example, Shockley Transistor Corporation was started with backing from Beckman Industries, while financing for Fairchild Semiconductor was provided by Fairchild Camera.

The early venture groups in the San Francisco Bay Area took on a variety of forms. The first venture capital firm in California, Draper, Gaither and Anderson, was founded in 1958 as a limited partnership. The following year saw the establishment of two federally leveraged SBICs, Continental Capital Corporation and Small Business Enterprises. Another SBIC, Draper and Johnson, was set up in 1962. The venture capital firm, Sutter Hill, was founded as the venture capital arm of a successful real estate development firm. Bank of America and a number of other commercial banks also provided venture financing for expanding businesses. In 1961, New York investment banker, Arthur Rock, formed a model limited partnership with Tommy Davis of Kern County Land Company. Of even greater significance was the revolving syndicate of independent investors centered around John Bryan and Bill Edwards which later came to be known as "the Group". One intermittent partner of "the Group," Reid Dennis, was able to persuade his employer, Firemen's Fund Insurance, to invest in a number of new ventures. The San Francisco Bay Area venture capital industry thus emerged from a period of active experimentation with different types organizations for providing venture capital. Faced with acute difficulties mobilizing funds and the need to share information and expertise, these early venture capitalists gradually evolved into an interactive

community trading information and participating together in rudimentary coinvestments.

The late 1960s and early 1970s saw the dramatic growth and reorganization of the Silicon Valley venture complex. Much of this expansion came from the original group of venture capitalists launching new venture capital funds.⁶⁰ Former entrepreneurs also became involved in venture capital. Eugene Kleiner of Fairchild Semiconductor was a co-founder of the important firm Kleiner Perkins in 1974, while Donald Valentine, an alumnus of both Fairchild and National Semiconductor, established Capital Management Services, Inc. (later Sequoia Capital) around the same time. A variety of other actors and institutions entered the Silicon Valley venture industry during this period. In 1968, Bessemer Securities became the first East Coast venture capital firm to open a California branch. Citicorp opened a West Coast office in 1973. The growth of Silicon Valley as an entrepreneurial center resulted in a shift in the locus of venture capital activity from San Francisco to Silicon Valley. By the 1970s, many of Silicon Valley's leading venture capital funds clustered in a new office complex at 3000 Sand Hill Road, Menlo Park which became the largest single enclave for venture capital in the United States,

This period saw the emergence of the limited partnership, with professional venture capitalists managing capital provided by passive outside investors, as the dominant model for venture capital. University endowments, financial institutions, and pension funds initially bet on venture capitalists with proven track records. Over time, a growing group of former entrepreneurs, past employees of venture firms, and outside personnel were able to attract financial resources and launch limited partnerships. The reduction in the tax rate on capital

gains and the liberalization of restrictions on pension fund investments were two reasons for this. The remarkable returns generated by the dozen or so original Silicon Valley venture funds sparked a massive surge of funds to venture capital partnerships. In contrast to venture capital in financial centers like New York and Chicago, the great bulk of Silicon Valley venture capital is invested in local companies. Furthermore, Silicon Valley's venture capital community grew up right alongside high-technology industry in a mutually-reinforcing and symbiotic way, similar to what occurred in the Boston textile industry or heavy manufacturing around Pittsburgh. Silicon Valley venture capitalists gradually insinuated themselves into developing entrepreneurial networks, bringing important financial resources and business development skills to those networks and hiring successful entrepreneurs.

As we have already seen, Boston was perhaps the nation's original source of venture capital.⁶¹ As early as 1911, the Boston Chamber of Commerce generated a small pool of risk capital and began providing managerial assistance to new enterprises.⁶² Later, in the 1930s, Boston retail magnate, Edward Filene and a group of New England businessmen launched the New England Industrial Corporation to provide organized assistance to new industries.⁶³ Boston was the home of American Research and Development (1946) the nation's first institutional venture fund which had been created by a prominent group of bankers and industrialists who saw such an entity as a way to more effectively finance technology-oriented enterprise.⁶⁴ In addition, a significant number of early venture capital investments in the Boston area were made by private individuals and wealthy families both from the Boston area and New York City.

By the early 1960s, large Boston financial institutions also became involved in venture capital. In the early 1960s, the major bank in the region, the First National Bank of Boston, "the Bank," established a program for providing loans to high technology businesses. First National Bank of Boston established a program for providing loans to technology oriented businesses and formed an SBIC affiliate. Other large banks established small business investment companies to invest in the technology-oriented businesses that were springing up in the region. Federal Street SBIC was established a consortium of Boston banks.

Both ARD and "the Bank" became important sources of spin-off funds. In 1963, for example, ARD alumnus, Joseph Powell founded Boston Capital Corp. By the 1970s, ARD alumni were instrumental in launching a host of top level partnerships including Palmer, Greylock, Charles River Partnership and Morgan Holland.⁶⁵ Another important development was the rise of TA Associates, currently the nation's largest venture capital fund with assets of \$1 billion plus dollars. In 1968, Peter Brooke left his position as director of "the bank's" high technology loan program to launch TA Associates. And, as TA Associates grew it begot a number of other partnerships such as Burr Egan and Deleage and Claflan Capital Management.

Boston, like Silicon Valley, thus witnessed the development of a technology-oriented venture community parallel to the emergence of the Route 128 entrepreneurial complex.⁶⁶ ARD's enormously successful investment in Digital Equipment Corporation (DEC) in the late 1950s provided a vital impetus to the climate for high technology entrepreneurship in Boston.⁶⁷ DEC played a significant role in the evolution of the Route 128 high technology center; it became an incubator for more than 30 spin-offs, most notably Data General.⁶⁸ As the

technology base of the Boston region developed, a host of partnerships were organized by veteran venture capitalists. The late 1970s and early 1980s also saw the formation of new funds such as Eastech and Zerostage and the movement of branch offices of funds headquartered elsewhere, such as Bessemer Venture Capital, to the Boston area.

The role of Route 128 venture capital community in financing new innovation is similar Silicon Valley, but the evolution of venture capital in the Boston area has been much more closely tied to large local financial institutions and wealthy families. In fact, venture capital in the Route 128 area was largely orchestrated by large business and financial interests, a far cry from the organic model of venture capital that grew up in and around Silicon Valley. Yet, like their counterparts in Silicon Valley, Boston venture capitalists also invest heavily in local high technology, bolstering that region's capacity to engender important new innovations.

Venture capital in the Silicon Valley and Route 128 evolved gradually alongside the high-technology industrial complexes that grew up there. Venture capital thus became an integral part of the regional technology infrastructure, or what has been elsewhere termed the social structure of innovation - an interactive system comprised of technology intensive enterprises, highly skilled human capital, high caliber universities, substantial public/private R&D expenditures, specialized networks of suppliers, support services such as law firms and consultants, strong entrepreneurial networks, and informal mechanisms for information exchange and technology transfer.⁶⁹ The synergies among the various elements of this infrastructure created a unique window of opportunity for the emergence of technology-oriented investing apart from traditional financial institutions. The growth of venture finance

then proceeded along a learning curve characterized by the gradual accumulation of investment and management skills on the part of venture capitalists and entrepreneurs alike. This in turn facilitated the development of extended entrepreneurial networks that became conduits for sharing information, making deals, and mobilizing resources. As a central component of such networks, venture capital thus played an important role in incubating entrepreneurial activity, attracting entrepreneurs, and accelerating rates of new business formation.

CONCLUSION AND DISCUSSION

The very phrase venture capital calls forth the image of new financiers of innovation who back cutting-edge high-technology concerns. These industrial enterprises are usually linked to some cutting-edge, industry-defining technology - biotechnology, advanced materials, computer software, and the like. Popular conventions aside, we tend to associate venture capitalism with the sweeping technological and economic revolution of the past two or three decades. But, venture capital has a much deeper and richer history than that. Indeed, the rise of new forms of finance to channel capital to new enterprise and new industries is a defining feature of the America's technological, industrial and economic development.

We started from the premise that new forms of finance, or more appropriately venture capital, are typically required to finance the birth of new technologies and business organizations, and the more general process of technological and industrial development. In other words, we suggested that the rise of new forms of finance, or venture capital, correspond to the rise of new industries and technologies. We aimed to essentially draw upon, expand and

test Schumpeter's seminal insights on the role of innovation in capitalist development. In Schumpeter's eyes, economic development is a process of discontinuous evolution which is driven by technological change. Major innovations or clusters of innovations set in motion strong "gales of creative destruction" which revolutionize industrial production and industrial organization. However, the risks associated with these major innovations are sufficient to deter average firms, so "exceptional entrepreneurs" are required to set such gales in motion. In our view, Schumpeter's risk-taking entrepreneurs require a symmetric counterpart in the financial system.

We believe that the historical record, at least for the American case, lends considerable support for this hypothesis. America's first industrial revolution of textile production in and around Boston both required and reinforced the rise of a new set of financial institutions that economic historians such as Lance Davis, Robert Dalzell, and Naomi Lamoreaux have variously referred to as relationship banking or equity-financed insider lending. New financiers of innovation similarly arose to finance the technology-based corporations and corporate complexes of the second industrial revolution: the activities of Andrew Mellon in financing Pittsburgh's industrial complex are illustrative of this process. During this epoch, a new and more complex system for banking and investment thus emerged as a vehicle for technological change and industrial development. The high-technology revolution of the mid-to-late twentieth century required yet another round of financial innovation and a new set of venture capitalists to bring to fruition. These new venture capitalists grew up alongside the high-technology innovation complexes of Silicon Valley and Route 128. By the 1980s, a new

and highly institutionalized national system for venture capital had emerged to finance the latest wave of entrepreneurial, technology-based enterprise. Simply put, venture capital is a defining element of the American pattern of technological change and industrial development.

The venture capital system itself evolved alongside American industrialism, becoming increasingly formal and institutional in character over time. The early venture capital or "insider lending" of the New England textile industry was largely a regional system, built upon close personal ties between the region's financiers and industrialists. The new forms of venture capital that emerged to finance America's second industrial revolution took shape as more formal institutions, such as Andrew Mellon's Union Trust Company. The high-technology venture capital of the mid-to-late twentieth century evolved into a more fully-blown institutional system of formal (indeed legal) organizations such as the limited partnership and its own set of trade associations and research organizations. Furthermore, this institutional system of venture capital evolved into a well-articulated national system for mobilizing capital via coinvestment syndicates and other mechanisms.

Our historical excursus thus lends considerable support to the view that the processes of finance or capital formation, technological change and industrialization occur in tandem over time. They can be seen as different "faces" of an overall development process which grow up together, influence and shape one another, and are to some degree inseparable. This can be thought of as a cumulative process as industrial growth generates new sources of capital which are in turn invested into subsequent rounds of industrial expansion and growth. With every major technological step forward, corollary shifts in finance occur and new forms of venture

finance are created. These new financial forms emerge in response to the of mismatch of capital and industrial needs, as older, more traditional forms of capital remain tied to older paradigms of industrial organization and growth. New mechanisms for providing capital - and new financiers of innovation - are required to support the rise of new technologies, new enterprises and new industries.

Furthermore, our findings suggest that place matters in the co-evolution of finance and industrial development. Here, we simply suggest that Schumpeter's fundamental insights have a considerable spatial or geographic dimension. As we have seen, major technological changes, or shifts in the organization of production tend to occur in specific places and diffuse unevenly across the industrial landscape. The growth and development of local industrial complexes in turns creates the expanding economic base, vibrant investment climate, and new opportunities for capital accumulation. The initial opportunities may well be filled by traditional financiers and investors in established financial centers especially given the well-developed financial structure of contemporary capitalism. Yet over time, the developmental trajectory of the new growth complex creates a momentum of its own, helping to create and indeed generate new sources of indigenous capital, finance, and investment articulated to the needs of its local industries. The new complex is now able to finance itself and embarks on a period of self-reinforcing growth while, at the same time, retaining connections to outside sources of capital and investment.

Our review of the historical record leads us to conclude that venture capital has played a rather fundamental role in innovation, industrial transformation and economic development.

Capital and creative destruction thus go hand in hand in the process of technological change and industrial growth in American economic history.

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- ² Joseph Schumpeter, Capitalism, Socialism, and Democracy (New York: Harper & Row, 1942) 83.
- ³ Schumpeter, Theory of Economic Development passim.
- ⁴ Schumpeter, Capitalism, Socialism, and Democracy 69.
- ⁵ Joseph Stiglitz, "Information and Capital Markets," in William Sharpe and Carolyn Cootner, eds. Financial Economics: Essays in Honor of Paul Cootner (Englewood Cliffs, NJ, 1982).
- ⁶ Lance Davis, "Sources of Industrial Finance: The American Textile Industry," Explorations in Entrepreneurial Economist 9 (April): 189-203.
- ⁷ Gunnar Myrdal's theory of cumulative causation, for example, views investment as a cumulative process governed by the existing distribution of productive activity and past investments--one which is characterized by small, incremental changes over time and space. See, Gunnar Myrdal, Economic Theory and Underdeveloped Regions (New York: Harper and Row, 1957). More recent historical scholarship documents the growing specialization of industrial and financial functions under capitalism and the rise of specialized financial centers in places like London and New York. In their classic account of the growth and development of the metropolitan New York region, Hoover and Vernon noted that the New York City financial district emerged as a series of specialized financial service centers tied to specific forms of industrial and merchant capital. See, Edgar Hoover and Raymond Vernon, Anatomy of a Metropolis (New York: Anchor Books, 1962) pp. 88-94. See also Allan Pred, The Spatial Dynamics of U.S. Urban-Industrial Growth, 1800-1914 (Cambridge: MIT Press, 1966) and Urban Growth and the Circulation of Information: the United States System of Cities, 1790-1840 (Cambridge: Harvard University Press, 1973) for a documented history of the rise of a small group of financial centers, (e.g., New York, Philadelphia and Boston) tied to specialized mercantile functions in the late 18th and early 19th centuries. Pred noted the role of large financial centers, such as New York and Boston, in performing such nodal functions in the U.S. financial system and documented the evolution of a spatially-dispersed but well-integrated national financial system with New York at its center. See also Michael Conzen, "The Maturing Urban System in the United States, 1840-1910," Annals of the Association of American Geographers 67 (1977): 88-108. More recent research on "corporate complexes" includes Thomas Stanback and Thierry Noyelle's Cities in Transition (Totowa, NJ: Allandheld, Osmun and Co. Publishers, 1982), Thierry Noyelle and Thomas Stanback, The Economic Transformation of American Cities (Totowa, NJ, 1984). Furthermore see James O. Wheeler, "Corporate Spatial Links with Financial Institutions: the Role of Metropolitan Hierarchy," Annals of the Association of American Geographers 76, 2 (1986): 262-274; See, Meric Gertler "Regional Capital Theory," Progress in Human Geography 8, 1 (1984): 50-81 and "Capital, Technology and Industry Dynamics in Regional Development," Urban Geography 8, 3 (1987): 251-263.
- ⁸ Paul B. Trescott's Financing American Enterprise: the story of commercial banking (New York: Harper and Row, 1963) is a seminal work on the credit side of banking and its role in the economic development of the United States. Additionally, Richard Sylla's The American Capital Market, 1846-1914 (New York: Arno Press, 1975) and Naomi Lamoreaux's The Great Merger Movement in American Business, 1895-1904 (New York: Cambridge University Press, 1985) are quintessential studies of the role of financing in economic growth.
- ⁹ On venture capital as a form of investment see Alden Bean, D. Schiffl and M. Moguee, "The Venture Capital Market and Technological Innovation," Research Policy 4 (1975): 380-408.

¹⁰ We suggest that finance, capital formation, and industrialization are not the product of abstract economic theories; rather they are informed by historical events and social institutions. Following Alexander Gershenkron and James Kurth on the comparative institutional structures of finance in the process of national economic development, we suggest that there are no single or optimal mechanisms for providing finance. The relationship between the political structure and the industrial sector essentially plays itself out in the various stages of product cycle development. Who performs the financial functions varies from country to country and even within some countries. Banks, the state, industrial corporations, and even decentralized financial systems composed of complex multiple sub-systems all provide capital. Simply put, there are multiple forms, or functional alternatives, which are formed by the actual process of historical and institutional development. In formal terms, the relationship between capital formation and industrial development is "path-dependent"--that is, informed by the particular historical path taken. See, James Kurth, "The Political Consequences of the Product Cycle: Industrial History and Political Outcomes," International Organization 33, 1 (Winter 1979): 1-34. See, Paul David, Technical Choice, Innovation, and Economic Growth (New York: Cambridge University Press, 1975). See also W. Brian Arthur, "Urban Systems and Historical Path Dependence," in J. Ausubel and R. Herman, eds., Cities and Their Vital Systems (Washington, DC: National Academy Press, 1988): 85-97.

¹¹ To some degree, we follow Lazonick and others who characterize American economic history as comprising three relatively distinct periods: (1) proprietary capitalism, (2) managerial capitalism alongside the vertically integrated corporation and Fordist mass production; (3) and the rise of the new high-technology industries, knowledge-based production, and/or collective capitalism. In periodizing the growth of U.S. industry we have drawn from William Lazonick's "Business Organization and Competitive Advantage: Capital Transformations in the Twentieth Century" (Second International Conference on the History of Enterprise, Terni, Italy, October 1-4, 1987). Lazonick lays out three stages of industrial and entrepreneurial growth, labeling them proprietary, managerial, and collective. Proprietary capitalism took root in England as it became the world's workshop and spread to the United States during the mid-nineteenth century. See also Lazonick, Competitive Advantage on the Shop Floor (Cambridge: Harvard University Press, 1990); Lazonick, Business Organization and the Myth of the Market Economy (New York: Cambridge University Press, 1991).

¹² See Alfred Chandler, The Visible Hand: The Managerial Revolution in American Business (Cambridge, MA: Harvard University Press). In Chandler's words: "The Visible Hand of management replaced the invisible hand of market forces where and when new technology and expanded markets permitted a historically unprecedented high volume and speed of materials through the processes of production and distribution." (Chandler: 12). See also David Hounshell's From the American System to Mass Production (Baltimore: Johns Hopkins University Press, 1984).

¹³ An increasing number of scholars have argued that the United States and international economies are in the midst of a third major period of technological, economic, and institutional restructuring. This has been variously termed flexible production, post-Fordism, lean production, and/or collective capitalism. See, Lazonick, Business Organization; and, Competitive Advantage on the Shop Floor Michael Piore and Charles Sabel, The Second Industrial Divide: Possibilities for Prosperity, (New York: Basic Books, 1983); Generally speaking, the contours of this new production system are: shifts in the main source of value creation from physical skill to intellectual capability, increasing importance of collective knowledge, accelerated innovation cycles, and greater reliance on continuous improvement on the shop floor which serves to blur the lines of distinction between R&D and the factory. See also Peter F. Drucker, Postcapitalist Society (New York: Harper Business, 1993). As management theorist Peter Drucker has argued, the foundation of capitalism is experiencing a fundamental restructuring, which will have significant effects on economic and social organization. Also see, Richard Florida and Martin Kenney, The Breakthrough Illusion, (New York: Basic Books, 1991).

¹⁴ This research was conducted jointly by Richard Florida and Martin Kenney, and is summarized in Florida and

Kenney, "Venture Capital-Financed Innovation in the USA," Research Policy, 17 (1988): 119-137; and idem., "Venture Capital, High-Technology and Regional Development," Regional Studies, (1988).

¹⁵ There is a vast literature on the modern-day venture capital industry, see for example, William Bygrave and Jeffry Timmons, Venture Capital at the Crossroads (Boston: Harvard Business School Press, 1990); Thomas Doerflinger and Jack Rivkin, Risk and Reward: Venture Capital and the Making of America's Great Industries (New York: Random House, 1987); John W. Wilson, The New Venturers: Inside the High-Stakes World of Venture Capital (Reading: Addison-Wesley Publishing Company, 1985); William Sahlman, "Insights from the American Venture Capital Organization," (Paper prepared for the Council on Competitiveness and Harvard Business School Time Horizons Project, 1991); Richard Florida and Martin Kenney, "Venture Capital-Financed Innovation in the USA." Research Policy 17, (1988): 119-37; William Janeway, "Doing Capitalism: Journal of Economic Issues 20, (1986): 431-41.

¹⁶ Indeed Venture Economics, defines venture capitalists as "participating investors seeking to add value through long-term involvement with continuing business development." See, Venture Capital Journal, March 1987.

¹⁷ Brook Hindle and Steven Lubar, Engines of Change: The American Industrial Revolution, 1790-1860 (Washington, D.C.: Smithsonian Press, 1986) 185.

¹⁸ Robert Dalzell, Enterprising Elite: The Boston Associates and the World They Made (Cambridge: Harvard University Press, 1987). See pp. 8-9 for a discussion of how Francis Cabot Lowell surreptitiously obtained the designs for the Cartwright power loom while on vacation in England and Scotland. See also Carolyn Ware The Early New England Cotton Manufacture (New York, 1931) and Paul McGouldrick, New England Textiles. Philip Scranton's Proprietary Capitalism: The Textile Manufacture at Philadelphia, 1800-1885 (New York: Cambridge University Press, 1983) presents an excellent commentary on the Lowell system in Chapter 2.

¹⁹ Dalzell, Enterprising Elite: 40.

²⁰ Dalzell, Enterprising Elite: 26-28.

²¹ Raymond Goldsmith, A Study of Savings in the United States, National Bureau of Economic Research Service, 3 volumes. (Princeton: Princeton University Press, 1955).

²² Naomi Lamoreaux, Insider Lending: 13.

²³ Lance E. Davis, Richard Easterlin, and W.N. Parker, American Economic Growth (New York: Harper and Row, 1972). See especially pp. 301-330.

²⁴ Thomas Cochran, "The Entrepreneur in American Capital Formation," in Capital Formation and Economic Growth, National Bureau of Economic Research Ser. (Princeton, 1955) 339-345.

²⁵ See, Douglass C. North, "International Capital Flows and the Development of the American West," Journal of Economic History XVI (December 1956): 493-505; Lance E. Davis, "Capital Immobilities and Finance Capitalism: A Study of Economic Evolution in the United States, 1820-1920," in Explorations in Entrepreneurial History 1 (Fall 1963): 88-105. See also Louis Hunter, "Financial Problems of Early Pittsburgh Iron Manufacturers," Journal of Economic and Business History (May 1930). For a thorough account of Boston elite financing the western railroads see Arthur Johnson and Barry Supple Boston Capitalists and Western Railroads (Cambridge, 1967).

²⁶ In addition, public trust in the banking system evaporated in the wake of the bank panic of 1857. The National Currency Act of 1863, which assured a national currency of private bank notes backed by treasury bonds, restored a modicum of public confidence and bank participation in financing enterprises through collateral notes increased significantly.

²⁷ Raymond Goldsmith, Financial Intermediaries in the American Economy Since 1900, National Bureau of Economic Research Ser. (Princeton: Princeton University Press, 1958);

²⁸ See, Chandler, The Visible Hand.

²⁹ Lance Davis, "Capital Immobilities." See also Glenn Porter and Harold Livesay, Merchants and Manufacturers: Business in the Nineteenth Century (Baltimore: Johns Hopkins University Press, 1971): 65-68; Louis Hunter "Problems of the Early Iron Manufacturers in Pittsburgh."

³⁰ See Davis, Easterlin, et al, American Economic Growth, for a discussion of the many ways industrialists sought to obtain capital to finance expansion. For an important account of the capital flow into and out of a nineteenth century industrial city see William Cronon's Nature's Metropolis: Chicago and the Great West (New York: Norton, 1991). Cronon gives an intricate account of the flow of capital between Chicago and the eastern financial centers. Significantly, Pittsburgh was an important creditor in the expansion of the Chicago manufacturing community. See also Charles K. Hyde, "From 'Subterranean Lotteries' to Orderly Investment: Michigan Copper and Eastern Dollars, 1841-1865," Mid-America 66, 1 (January 1984): 3-20 presents the argument that places like Pittsburgh speculated in the mining commodities of frontier regions.

³¹ See, Vincent Carosso, Investment Banking In America: A History (Cambridge: Harvard University Press, 1970) 32.

³² Vincent Carosso, Investment Banking in America 108-109. Sophistication on the part of investment bankers was necessary to accommodate the investment needs of these new firms, thus existing brokerage firms diversified and new niche markets developed in the financial services industry. See Also Barry Supple "A Business Elite: German-Jewish Financiers in Nineteenth-Century New York," Business History Review 31 (Spring 1957): 143-178, for a discussion of the importance of foreign investment, which even more heavily depended on personal relationships and close-knit groups. Foreign capital became a widespread option for cash starved manufacturers in the mid nineteenth century and remained so into the twentieth. Participation by financiers such as Cornelius Vanderbilt, John Jacob Astor, or John Murray Forbes was a sufficient guarantee to attract foreign investors. This bred familiarity of the older established European financial institutions like the Rothschilds and Lloyds with American financiers such as J.P. Morgan, William Vanderbilt, Henry Villard, and Nathaniel Thayer. In addition, enclaves of immigrant groups in Boston, New York, and Philadelphia maintained close ties with their home countries in Europe gaining access to capital in the old country.

³³ See, George Harvey, Henry Clay Frick: The Man (New York: Charles Scribner's & Sons, 1928). See also John Ingham, "Henry Clay Frick," in The Encyclopedia of American Business History and Biography (New York, 1988): 124-125.

³⁴ See, Junius Edwards, A Captain in Industry (New York, 1957) 40-41. Hall was unable to attract investors because the expense for generating enough electric current to produce merely a pound of commercially viable aluminum was too high. Thus in small-scale demonstrations Hall could not achieve the reduction he needed.

³⁵ Four other men also were part of the original company. Two were from Carbon Steel Company, one was from

Carnegie Steel Company, and one from the Pittsburgh Testing Laboratories. Hunt and Clapp both worked for the Park Brothers Black Diamond Steel Works as metallurgical engineers. In 1882, Black Diamond hired two college graduate engineers, William Kent and William Zimmerman, who formed a department in the company known as the Pittsburgh Testing Laboratory for the Testing of Materials and Engineering Inspections. Hunt and Clapp worked in that division of Black Diamond. In 1886, Hunt and Clapp spun-off the company, gained full title to it, and renamed it the Pittsburgh Testing Laboratory.

³⁶ David T. Bieto, "Andrew Mellon," in The Encyclopedia of American Business History and Biography. pp. 267-282. See also O'Connor, Mellon's Millions 79-81.

³⁷ Mellon also tried to take a considerable equity in Westinghouse. When Mellon was approached by George Westinghouse in late 1891 to provide \$500,000 to finance a new air brake plant, Mellon demanded a high level of equity in his air brake and electrical equipment divisions, as well as latitude to name his own general manager. Westinghouse found this untenable and turned toward the New York financial community for help. Burton Hersh, The Mellon Family: A Fortune in History, (New York: William Morrow & Company, 1978). Westinghouse came away from the deal empty handed, and with a bitter distaste for the baronial Mellons and the whole Pittsburgh capital financing scene. Westinghouse had been given a similar ultimatum in 1869 by Robert Pitcairn when he sought to start up the air brake company. Andrew Mellon vowed never to allow a Pittsburgh manufacturing firm slip away from his financial control, and to one day control the Westinghouse company.

³⁹ Although Union Trust proved to be lucrative beyond anyone's imagination, Andrew's initial wealth was built up from his father's real estate and banking activities, and his brothers' construction and lumber company. David E. Koskoff, The Mellons: The Chronicle of America's Richest Family (New York: Thomas E. Crowell Publishers, 1978). It seems the Judge had a reputation for being a prudent and difficult lender who rarely dirtied his hands with disreputable businessmen. The fact that Judge Mellon ensured that "investments covered almost every phase of commercial activity" was not lost on the Andrew and Richard during their forty year reign over investment capitalism in Pittsburgh. See also William Larrimer Mellon and Boyden Sparkes, Judge Mellon's Sons (privately printed, 1948). When Andrew Mellon assumed the Secretary of the Treasury in 1919, his longtime friend and legal advisor Philander Knox advised him to relinquish all formal ties to his financial and industrial empire. As a result he resigned from the boards of more than fifty national corporations, including Gulf Oil, Mellon Bank, Alcoa, Standard Steel Car, American Locomotive Co., and the Crucible Steel Company of America. His brother Richard B. Mellon remained at the helm of the Mellon empire. Eventually there were Congressional hearings in 1925 to determine what if any undue influence Andrew Mellon had over his former investments. For an account of these hearings see the muckraking story by Harvey O'Connor in Mellon's Millions: The Life and Times of Andrew W. Mellon (New York: John Day, 1932).

⁴⁰In 1915, the Koppers Company became another part of the Mellon family of firms, and enjoyed extensive interlocks with other giant enterprises like McClintic-Marshall Construction Co. and Crucible Steel Co. Two years later, after American involvement in the war became inevitable, the Alien Property Act was applied to Heinrich Koppers' investments in the company. His shares were sold at auction in the Mellon-controlled Pittsburgh Stock Exchange on September 13, 1918. Andrew Mellon paid \$300,000 for Koppers' 3000 shares, which represented their 1914 value plus interest. On the day he gained title, the market value of the stock exceeded \$3,000,000. Andrew W. Mellon not only pulled off a managerial coup in gaining nearly complete voting control of the Koppers Company, but realized a phenomenal profit as well.

⁴¹ McClintic-Marshall set its sights on the lucrative Ambridge unit of Carnegie Steel, Union Steel competed

directly with finished steel products such as those manufactured by American Steel and Wire, and Standard Steel Car competed with Pressed Steel Car after Carnegie forced Henry Oliver and Charles T. Schoen out of that company in 1901. The Crucible Steel Co. endeavor and the organization of Union and Donner Steel to produce wire and finished steel products at Donora, PA permanently changed the concentration of power in the steel industry. Crucible Steel pulled together the loosely held alliance of independent steel producers. The Union Steel Company recruited Henry C. Frick, just ousted from Carnegie Steel. Joseph Frazier Wall, Andrew Carnegie (Pittsburgh: University of Pittsburgh Press, 1971). See the detailed account on pp. 724-737. Also see John Ingham, Making Iron and Steel: Independent Mills in Pittsburgh, 1820-1920 (Pittsburgh: University of Pittsburgh Press, 1990) 140-147. Also see Harvey O'Connor, Mellon's Millions 64-78.

⁴² Harvey O'Connor, Mellon's Millions 62. Capital of the company had been increased from \$1,000,000 to \$45,000,000 after Mellon negotiated to purchase the Sharon Steel Corporation and announced plans to build a new mill at Donora on the Monongahela River. Rather than compete head on with Union Steel, which would have "disturbed industrial conditions which the Steel Corporation sought to establish" the directors of U.S. Steel authorized the purchase of Union Steel from Mellon.

⁴³ Despite all their dealings outside of the metalworking sectors of Pittsburgh's industry, Mellon's eventual investments in the Crucible Steel Company of America, McClintic-Marshall Construction Company, and the Standard Steel Car Company indicate his attempt to benefit from the agglomerative advantages of steel production in Pittsburgh. Mellon came to control McClintic-Marshall in a manner similar to his ownership of the Pittsburgh Reduction Company. In 1899 two engineer-inventors, Howard McClintic and Charles Marshall, approached the Mellons looking for a loan to start a new business. Both gained experience in structural steelmaking and bridge construction at the region's leading bridge firms (Ambridge, Fort Pitt Bridge Works, and Keystone Bridge). Interestingly, the Ambridge and Keystone Bridge firms were part of the Carnegie Steel empire. Aware of the skyscraper building boon, and recognizing the potential to compete with industry leaders, Mellon offered his financial resources in exchange for equity participation and management control. He (and three other partners) retained ownership of the company until 1932 when it was sold to the Bethlehem Steel Company.

⁴⁴ See, Martha Louise Reiner, "The Transformation of Venture Capital: A History of Venture Capital Organizations in the United States," (University of California, Berkeley: Ph.D. Diss., 1989): 161. Also, see John Wilson, The New Venturers (Reading, Massachusetts: Addison-Wesley Publishing, 1985): 44-59. Neither firm stayed away from the investment banking business. Nine partners from J.P. Morgan left to form the Morgan Stanley Co. and the lead partner in Brown Brothers Harriman Co. left to form Harriman Ripley & Co. Both of these new firms were investment banking houses engaged in managing syndicates and wholesaling securities to dealers and other investment houses. Both also shared directors with their private banking cousins. In the Mellon constellation of financial stars---Union Trust and Mellon Bank---a return to the core business of trusteeship and commercial banking accompanied the formation of two new institutions to fill in the withdrawal of Union and Mellon from investment banking and savings & deposit functions in 1934. Mellbank became the umbrella under which local savings banks operated, and Mellon Securities continued the Mellon family's involvement in the investment banking business.

⁴⁵ Wilson devotes considerable attention to some of the new industries financed by J.H. Whitney & Co. and other new venture capital syndicates that emerged in the 1930s and took off after the Second World War. See, Wilson, The New Venturers, 19-29.

⁴⁶ See, Simon Kuznets, Capital in the American Economy: Its Formation and Financing National Bureau of Economic Research Service (Princeton: Princeton University Press, 1961). These segmentations included: Federal Reserve Banks, commercial banks, savings banks, savings and loan associations, credit unions, Postal savings system, personal finance companies, life insurance companies, private pension funds, federal pension funds, land

banks, mortgage companies, investment companies, investment bankers, securities brokerage houses, government lending institutions, and trust funds. See also John Kenneth Galbraith's The Great Crash, 1929 (Boston: Houghton Mifflin Co., 1954), for perhaps the most insightful account of the 1929 stock market crash and its aftermath.

⁴⁷ Ralph Flanders, "The Problem of Development Capital," Commercial and Financial Chronicle (November 29, 1945).

⁴⁸ See, Committee on Economic Development, Meeting the Special Problems of Small Business (New York: McGraw Hill Co., 1947)

⁴⁹ Edwin George, "Can Small Business Get the Capital They Need?," Dun's Review, (October, 1952). See especially p. 141.

⁵⁰ See, Committee for Economic Development, Meeting the Special Problems of Small Business (New York: Committee for Economic Development, 1947); A.D.H. Kaplan, Small Business: Its Place and Problems (Committee for Economic Development Research Study, New York: McGraw-Hill, 1948).

⁵¹ This should come as little surprise given its historical commitment to industrial-academic partnerships, dating back to the vision of MIT benefactor, William Barton Rogers. During the 1930s, MIT began to look into direct industrial partnerships with companies like Raytheon.

⁵² On MIT's interaction and involvement with high-technology industry see, Stuart Leslie, The Cold War and American Science (New York: Columbia University Press, 1992); and Henry Etzkowitz, "MIT's Relations with Industry: Origins of the Venture Capital Firm," (Working paper, SUNY-Purchase, 1990).

⁵³ On the history of ARD see, Patrick Liles, Sustaining the Venture Capital Firm (Cambridge, MA: Harvard university, Management Analysis Center, 1977).

⁵⁴ Venture Capital Journal November 1974 and Venture Capital Journal June 1979.

⁵⁵ Venture Capital Journal June 1979.

⁵⁶ Our discussion of New York venture capital is based upon oral interviews and back issues of Venture Capital Journal.

⁵⁷ Venture Capital Journal June 1975.

⁵⁸ See, Gene Bylinsky, The Innovation Millionaires (New York: Charles Scribner's Sons, 1976) 29.

⁵⁹ There is a substantial body of literature which addresses the development and organization of high-technology industry in Silicon Valley, see, Annalee Saxenian, Regional Advantage: Culture and Competition in Silicon Valley and Route 128 (Cambridge: Harvard University Press, 1994); Everett Rogers and Judith Larsen, Silicon Valley Fever: Growth of a High-Technology Culture (New York: Basic Books, 1984); Michael Malone, The Big Score (New York: Doubleday, 1985); Paul Frieberger and Michael Swaine, Fire in the Valley: The Making of the Personal Computer (Berkeley, CA: Osborne-McGraw Hill, 1984); Dirk Hanson, The New Alchemists: Silicon Valley and the Microelectronics Revolution (Boston: Little Brown, 1982). For a historical perspective, see, Leslie, The Cold War and American Science; Arthur Norberg, "The Origins of the Electronics Industry on the Pacific Coast," Proceedings of the Institute of Electrical and Electronics Engineers 64, 9 (September 1976): 1314-22; Tim Sturgeon, "Origins of

Silicon Valley: The Development of the Electronics Industry in the San Francisco Bay Area," (Master's Thesis, Department of City and Regional Planning, University of California at Berkeley, 1992). A suitable antidote to the boosterish quality which is typical of much of this genre of literature can be found in Dennis Hayes, Behind the Silicon Curtain (Montreal: Black Rose Books, 1990).

⁶⁰ In 1968, for example, Bryan and Edwards was established and George Quist of Bank America set up Hambrecht and Quist. In 1974, Reid Dennis founded Institutional Venture Associates with Burton McMurtry of Palo Alto Investment. Two years later, Institutional Venture Associates split into two partnerships, McMurtry's Technology Venture Associates and Dennis' Institutional Venture Partners. Tommy Davis launched the important Mayfield Fund in 1974.

⁶¹ Our discussion of Boston venture capital draws mostly from personal interviews with venture capitalists in the Boston area conducted by Richard Florida and Martin Kenney. See, Russell Adams, The Boston Money Tree for a discussion of early efforts. The early history of ARD is chronicled in Patrick Liles, Sustaining the Venture Capital Firm (Cambridge, MA: Management Analysis Center, 1977). Back issues of Venture Capital Journal (especially March 1974, August 1975, November 1976) describe the formation of a number of funds.

⁶² For the early history of venture finance in Boston, see, Russell Adams, The Boston Money Tree (New York: Thomas Crowell, 1977).

⁶³ See, William Leavitt, "Small Business Wants Capital," Harvard Business Review 18, (Spring 1940): 265-74.

⁶⁴ See, Patrick Liles, Sustaining the Venture Capital Firm 28-36.

⁶⁵ Venture Capital Journal March 1974, August 1975, and November 1976.

⁶⁶ The Route 128 technology complex has been the subject of a considerable literature. See, for example, Susan Rosegrant and David Lampe, Route 128: Lesson's from Boston's High-Tech Community (New York: Basic Books, 1992); Edward Roberts, Entrepreneurs in High Technology: MIT and Beyond (New York: Oxford University Press, 1991); David Lampe (ed.), The Massachusetts Miracle: High Technology and Economic Revitalization (Cambridge: MIT Press, 1988); Nancy Dorfman, "Route 128: The Development of a High-Technology Region," Research Policy 12, 6 (December 1983): 299-316; Dorfman, Massachusetts' High-Technology Boom in Perspective: An Investigation of Its Dimensions, Causes and the Role of New Firms, (Cambridge, MA: MIT, Center for Policy Alternatives, 1982).

⁶⁷ On DEC see, Glenn Rifkin and George Harrar, The Ultimate Entrepreneur: The Story of Ken Olsen and Digital Equipment Corporation (Rocklin, CA: Prima Publishing, 1990).

⁶⁸ See, Nancy Dorfman, 1983.

⁶⁹ See, Richard Florida and Martin Kenney, "Venture Capital, High Technology, and Regional Development," Regional Studies 22, 1 (1987): 33-48.