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VENTURE CAPITAL AND THE INVENTIVE PROCESS

VC Funds for Ideas-Led Growth

Tamir Agmon and Stefan Sjögren

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Tamir Agmon
University of Gothenburg
Göteborg, Sweden

Stefan Sjögren
University of Gothenburg
Göteborg, Sweden

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List of Abbreviations

VC	Venture Capital
LP	Limited Partner
GP	General Partner
IPO	Initial Public Offer
GDP	Gross Domestic Product
R&D	Research and Development
ERISA	The Employee Retirement Security Act
DC	Defined Contribution
DB	Defined Benefit

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CHAPTER 1

A Comprehensive Economic Look at VC Funds

Abstract The inventive process by which innovative ideas in technology are turned into economic growth is the most important economic process of the last 200 years. The venture capital industry and the venture capital (VC) funds at its core are a small but important part of the inventive process that leads from an innovative idea to both increased consumption and an extension in consumption possibilities. The main proposition of this book is that by discussing VC funds in the context of the inventive process, we can better understand the venture capital industry and the way that VC funds operate. Discussing VC funds in the context of the inventive process requires bringing together different aspects of economics and finance and weaving them into a complete picture.

Keywords VC funds • inventive process

1.1 Introduction: The Purpose of This Book

The inventive process that began at the end of the eighteenth century with the first industrial revolution and continues to this day is the most important single feature of the economic and the social growth of the world in which we live. The main outcome of the inventive process has been a continuous growth of world population, coupled with a growth of income per capita. Beginning with the industrial revolution, a wide array of new innovative ideas in technology have been expressed in new products. New

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goods and services and new production technologies that change the way people live in the world have come into being. As a consequence of the agglomeration of the world's ever-rising population into industrial centers, new cities and states have risen continually from the ashes of the old. In this way, even the lines on the map were and continue to be influenced by the inventive process.

The venture capital industry and the venture capital (VC) funds at its core are a small but important part of the inventive process that leads from an innovative idea to increased consumption and an extension in consumption possibilities. The important role of VC funds and the VC industry in the inventive process justifies what seems to be a disproportionately large interest in the venture capital industry in general and in VC funds in particular in the business world, in academia, and in the public in large.

There are, of course, different answers as to why the venture capital industry gets so much attention. One answer is that VC funds turn radical innovative ideas into major components of economic growth. In the world of today, these changes are rapid and affect the life of everybody. People find such changes fascinating. An example of a VC-backed radical change is the development of Apple, Inc. In 1978, two VC funds, Sequoia and Matrix Partners, invested about $1.2 million in Apple at $3 million in pre-money valuation. At the time, Apple was one of many early-stage start-ups in California. Apple went public on December 22, 1980 and sold 4.6 million shares at $22 each for $101.2 million. The price went up that day by 32 %, leaving a market value of $1.7 billion. Today (mid-2016) the market value of Apple Inc. is more than $600 billion. In the process, Apple changed the lives of many people. This is heady stuff. A second answer is that the general partners (GPs) who manage VC funds are making a lot of money, even relative to other senior professionals in the financial services industry in the U.S. This type of rapid financial success always makes a good story.

In this book, we focus on a third answer as to why VC funds are of general interest: VC funds provide an important ingredient for economic growth in the U.S. and in the rest of the world. The main proposition of this book is that by taking a comprehensive look at VC funds in the context of the inventive process we can better understand the venture capital industry and the way that VC funds operate. A comprehensive look at VC funds requires bringing together different aspects of economics and finance and weaving them into a complete picture. Once VC funds are placed in the context of the long-term inventive process and economic growth issues, we are able to better understand why VC funds are of such general interest. Light is also shed on a multitude of sub-issues. For instance, how do VC funds raise capital and why are institutional investors the main source of capital for VC funds? What is the rate of return on the investment in VC funds from the point of view of the providers of the capital? How does the government intervene in the market in which VC funds operate? What is the contribution of VC funds to society at large?

The book is motivated by three observations about VC funds. The first observation is about developments in the market like the introduction of the Internet, or the development of semiconductors. The second observation is about intellectual property (IP) laws, the growth of basic research, and the development of institutional savings. The third observation is about the success of VC funds. The three observations are described briefly below. The implications of the three observations on the venture capital industry and on VC funds are discussed in detail through the book.

1.2 Radical Ideas as Assets

At any given point in time, there are a finite number of assets on the market. These assets together form the universe of all possible investment possibilities that in combination construct the market portfolio. The market portfolio is not static. There is a process by which new radical ideas are turned into new assets that generate new current and future consumption streams. Radical innovative ideas not represented by current assets are generated by people all the time. A small number of these ideas are selected by researchers and are developed further. The selected number of radical ideas are developed further by entrepreneurs, and a small fraction of those are selected by VC funds that develop them even further, testing their business viability and commercial potential. If successful, the investment by VC funds in radical ideas makes them into assets that increase the value of the market portfolio by adding new assets that were not part of the market portfolio prior to the selection and development process by VC funds. Adding new assets and thus extending consumption possibilities is the way in which radical innovation contributes to growth, where some ideas will be developed into commercial products and sold to consumers, and other ideas will be formed into platforms for numerous amounts of other ideas. There is a basic difference between the assets already in the market portfolio and what might be called “assets in process”. When using standard financial valuation tools, the returns generated by the assets in the market portfolio are assumed to follow and be described by a symmetric normal distribution. The returns that may be generated by "assets in process" based on radical ideas do not match this assumption and are instead better described by a binomial distribution. This is the case because "assets in process" based on radical ideas will become assets in the market portfolio only if the development of the idea is successful. If not, the idea will disappear and will not become a part of the market portfolio, and the investment in this radical idea will yield no value.

1.3 The Need for Government Interventions as a Necessary Condition for the Development of Radical, Innovative Ideas in Technology

Ideas are different from other goods. Ideas are non-rivalrous and have increasing returns to scale. That makes ideas like a public good (see e.g. Boldrin & Levine, 2005; Cornes and Sandler, 1986; Romer, 1998; Boldrin & Levine, 2005). A necessary condition for investors to invest in the risky development and commercialization of radical ideas is the ability to appropriate some of the public benefits to themselves. This requires government intervention in the form of allowing economic rents to the generators and the developers of successful radical ideas. The need for government intervention in the market for radical innovative ideas is acknowledged in the U.S. Constitution as well as by the legal codes of most developed countries. Governments also intervene in the market for ideas via public R&D spending and basic research funding with the purpose of increasing the number of ideas that can be turned into commercial products.

1.4 The Functional Role of VC Funds in Financing Radical Ideas

VC funds have played an important part in financing the development, testing, and early commercialization of radical innovative ideas in the ICT and the pharma industry. The successful early-stage and later rounds of investments financed by VC funds developed into major new assets in the market portfolio. New industries like semiconductors and new companies like Microsoft, Facebook, and eBay are examples of the connection between early investment by VC funds and major increases in consumption possibilities later on. A large number of unsuccessful investment projects by VC funds disappeared and did not become new assets. Both the successes and the failures are necessary parts in the process by which VC funds finance radical ideas. In this book, we use different analytical frameworks. One such framework is the functional and structural finance view developed by Merton and Bodie (2005). Instead of viewing VC funds and the general partners that manage them as atomistic actors in perfect markets, we analyze how the VC industry has evolved as a functional response to institutional changes and monopolistic competition.

1.5 The Narrative of the Book and Its Structure

As was stated above, we adopt a comprehensive approach to the venture capital industry and to VC funds, treating them as a small but important link in the chain of individuals and organizations that generate, select, develop, and commercialize radical innovative ideas in technology. This process, plus the much bigger process of incremental innovation by already existing firms and other organizations, is what drives the unprecedented economic growth since the beginning of the nineteenth century. The narrative of the book focuses on the way that the main components of the inventive process and the specific needs of the main actors that drive this process form the venture capital industry and the structure and mode of operations of VC funds. The focus of the current literature (see Denis, 2014 and Lerner & Tåg, 2013 for an extensive overview of the literature) is on the GP (see Kaiser & Westarp, 2010; Kaplan & Lerner, 2009), also known in the literature as a "Venture Capitalist", as the initiator of the investment by VC funds and claims that the structure and mode of operations of VC funds are the result of unique characteristics of GPs. The specific talents of GPs include but are not limited to the following: low search costs (Chan, 1983), choosing and writing contracts with entrepreneurs (Hellman, 1998; Hellman & Puri, 2002; Kaplan & Strömberg, 2002, 2004; Kaplan, Sensoy, & Strömberg, 2009), closely monitoring and stage funding processes (Admati & Plfeider, 1994; Hellman, 1998), and the ability to reduce the time to bring products to the market (Hellman & Puri, 2000). The talents of the GPs are part of the special features of VC funds that make VC an institution that spurs innovative activity (Kortum & Lerner, 2000) and complements the traditional R&D activity taking place within existing firms (Lerner, 2009). Our approach differs from the central theme of the current literature on VC funds. Throughout this book, the view is that the VC fund is as an institutional response to the need to finance the process from radical ideas to consumption. This narrative is expressed in the following eight chapters of the book.

Chapters 2 and 3 introduce and discuss the venture capital industry and VC funds in two ways: in Chap. 2 we discuss the size of the industry according to a number of measurements: the number and size of VC funds, capital raised and assets under management, the number of people employed by VC funds, total investment and number of investment projects, and the preferred industries for VC investment in different years. VC funds are financial intermediaries. They receive capital from savers either through institutional investors or directly and then transfer the capital to a specific class of investments: early-stage, high-risk investments and follow-up investments. VC funds are small relative to other financial intermediaries. The size of the venture capital industry and the number and size of the VC funds within it reflect the small share of "assets in process" (radical ideas that if successful will become assets in the market portfolio) in the total portfolio of the savers. The origin of VC funds was in the U.S., but in recent years VC funds have become global. Still, most of the venture capital industry is in the U.S. For that reason most of the discussion in Chap. 2 and later on uses U.S. data.

In Chap. 3 we provide an illustration of the role of VC funds in the process of turning ideas into assets that contribute to future consumption. The purpose of the illustration is to show one well-known and important complete process before discussing different aspects of the venture capital industry and VC funds. The semiconductor industry was chosen for the following reasons: it is relatively easy to trace the history of the industry from an idea to products, it is possible to show the contribution of VC funds to the development, testing, and early commercialization of the radical ideas that were at the basis of the semiconductor industry, and it is possible to measure the contribution of the semiconductor industry to current and future consumption.

In the next five chapters, we discuss five related dimensions that together comprise the environment in which VC funds operate, an environment that determines the structure of VC funds and their mode of operations. In Chap. 4 the focus is on the economic growth process in general and on the ideas-led growth process in particular. The connection between ideas and growth is discussed in this chapter, as well as the role of radical ideas in the growth process. People and organizations are involved in this process, and as it was illustrated in Chap. 3, it takes a long time to move from an idea to concrete products, services, and production technologies that affect consumption. VC funds have a small but important part in the growth process. Through their investments, VC funds connect government-funded basic research in its early stages to capital markets and large-scale production.

In Chap. 5 the focus is on the forms that government intervention takes and in what way the structure of both the liabilities and the assets of VC funds is a response to the intervention policy of governments in the field of promoting radical innovative ideas in technology. Governments intervene in the process of turning radical ideas in innovative technology into consumption by funding basic research, by enforcing intellectual property (IP) laws, and by encouraging and supporting long-term institutional savings. The first form of intervention increases the supply of radical ideas in innovative technology. The second form affects the value of assets based on radical ideas if successful. The third form of intervention makes it easier to finance VC funds by institutional investors. In this way, government intervention affects both the liabilities and the assets of VC funds. For example, the combined effect of the contract between Limited Partners (LPs) and GPs in VC funds and the temporary and contestable monopoly awarded to successful investment projects by VC funds as a result of IP laws brings about investment decision rules for VC funds that maximize the value of their investment projects conditional on success.

Chapter 6 is titled "How the Contracts between the Limited Partners (LPs), the General Partners (GPs) and the Entrepreneurs Facilitate Investments". The focus of this chapter is on VC funds as firms. Although VC funds are financial intermediaries, they operate like firms and their structure is determined by a nexus of explicit and implicit contracts between those who provide the necessary inputs to VC funds. Like any other firm, a VC fund is comprised of assets and liabilities. VC funds are special-purpose financial intermediaries that specialized in high risk "assets in process," which in turn are based on radical innovative ideas in technology. The flow of funds moves from the sources of funds (the savers) to the uses of funds (the investment projects). The investments by VC funds are limited by how much capital the institutional investors and others like family offices who provide the capital are willing to allocate for this purpose. As we have pointed out in the brief discussion of "assets in process" above, the risk of these assets is high and, more importantly, is different than the risk of assets already in the market portfolio. The providers of the capital, i.e. the investors in VC funds, control this risk by allocating a small part of their portfolio for this purpose and by designing a specific contract with those who decide in which projects to invest. The decision makers in VC funds are the GPs. The contract between the LPs and the GPs is the cornerstone of VC funds. This contract determines to a great extent the projects that GPs of VC funds are looking for. The GPs then sign a contract between the VC fund and the entrepreneurs in which the VC fund invests. Both the contracts between the LPs and the GPs and the contracts between the GPs and the entrepreneurs have explicit and implicit parts and together they determine the operations of VC funds.

In Chaps. 7 and 8, such investment decision rules are shown to be optimal for all parties involved in VC funds: the LPs, the entrepreneurs and the GPs. Financial intermediaries have fiduciary obligations to their beneficiaries. In Chap. 7 the focus shifts from VC funds to their main source of capital – institutional investors. The discussion focuses on pension funds in general and to public pension funds in the U.S. in particular. Institutional investors are the main source of capital for VC funds. Yet, institutional savings and institutional investors like pension funds are a new phenomenon that has started in the U.S. at the beginning of the twentieth century. The development of institutional savings went hand in hand with the development of the middle class in the U.S. The middle class accounts for most consumptions and savings today. It took the telephone 71 years to reach 50% of the American households; contrastingly, it took the Internet 10 years to reach this level of use. Therefore, the development of institutional investors in the U.S. is relevant to the growth of VC funds that draw a substantial proportion of their capital from asset allocation by institutional investors. Savings behavior is analyzed and discussed in the economic literature by what is known as the life-cycle savings model (Bodie et al., 2007). The objective of savings, according to the model, is to maximize the utility of lifetime consumption (including intergenerational transfer). Allocating a small fraction of one's savings to "assets in process" with their high risk of all or nothing is congruent with such a model, if the prize in case of winning is large enough. Friedman and Savage (1948) argue that highly risky projects that will change the life of a person if the project succeeds justify risk-loving investment rules. The potential of metamorphic change of radical ideas in innovative technology justifies a small asset allocation to such investment. Large increases in consumers' surplus as a result of successful investments in radical ideas like the Internet justify a small allocation of savings for this purpose. However, pension funds and other institutional investors do not measure the utility of the lifetime consumption of their beneficiaries and their goals are measured in terms of financial return on their portfolio. For example, CalPERS, the largest public pension fund in the U.S., defines its objective as a three years average return on its portfolio, where the target return reflects the risk of the portfolio measured in comparison to the total market portfolio. The question is, what is the return to institutional investors (LPs of VC funds) on investment in VC funds and is the actual return sufficiently high to compensate for the risk haunts the venture capital industry? The return on the investment in VC funds by their LPs is measured over the total investment in the VC fund over the life of the fund, typically 10–12 years where money goes in and out during this period. The Kauffman Report (2012) claims that the return to the LPs is too low relative to the risk. The issue of how the valuation of VC funds should be done and what is the appropriate way to measure the return on the investment by LPs in VC funds, as well as the allocation of value by VC funds to different stakeholders is discussed in Chap. 8.

Chapter 8 is titled, “Externalities, Consumers’ Surplus and the Long-Term Return on Investments by VC Funds”. All the literature that deals with the definition of the measurement of the return on the investment in VC funds measures the return to the LPs over the relevant horizon of VC funds. The return on the investment of LPs in VC funds depends on the success of the investments of the VC funds in “assets in process”. The success is the result of either an Initial public offer (IPO) or an acquisition of successful projects of VC funds by an existing company. This is known as an exit. An exit transfers “assets in process” to the market portfolio. The exit changes the probability distribution of the project (the asset) from binomial to normal. This is because the exit separates the “assets in process” to two groups, successful and unsuccessful. The *ex-ante* binomial distribution of the “assets in process” is not relevant for the *ex-post* successful projects that are now a part of the market portfolio. However, adding the successful projects to the market portfolio has externalities and it increases the return on some assets already in the portfolio, and an increase in the return which is not captured by the exit. The portfolio of institutional investors mimics the market portfolio. Therefore, they capture both the return to the LPs that represent them and the post-exit externalities through their holdings in the post-exit market portfolio. The measurement of the return on investment in VC funds by institutional investors by the return to the LPs is incomplete. The post-exit return explains why institutional investors should continue to allocate assets to

VC funds with what appears as insufficient compensation for the risk from a societal point of view. The contribution of the successful projects of VC funds to the value of the other assets in the portfolio post-exit creates an incentive for institutional investors, if the free rider problem is overcome, to allocate capital for the high-risk investments in the development testing and commercialization of radical ideas in innovative technology: an allocation which is congruent with optimal lifetime savings decisions by households.

The last chapter of the book, Chap. 9, is titled, "The Future of VC Funds: The Effects of Technology and Globalization". The chapter is a preliminary discussion of the direction that the venture capital industry and VC funds may take in the future. We see two major developments: technology and globalization. The relevant development in technology is digital platforms that change the structure and organization of firms and may have an effect on financing through crowdfunding. Globalization introduces new actors into the venture capital markets. China, India, and Brazil have become relevant markets in addition to the U.S. and Europe. These changes may change the nature of VC funds and create new intermediaries in the future, in the same way that technology and social policy in the U.S. create VC funds as we know them today.

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CHAPTER 2

The Size and the Characteristics of the Venture Capital Industry

Abstract In this chapter, we discuss the size of the VC industry along a number of dimensions: the number and size of VC funds, the amount of capital raised and assets under management, the number of people employed by VC funds, the total investment and number of investment projects, and the preferred industries in different years. VC funds are financial intermediaries. They receive capital from savers either through institutional investors or directly, and then transfer that capital to a specific class of investments: early-stage, high-risk investments and follow-up investments. VC funds are small relative to other financial intermediaries. Yet, they fulfill an important function. The presentation of the venture capital industry and VC funds in this chapter focuses on the U.S.

Keywords VC funds • VC industry

2.1 Introduction

This chapter aims to give a description of the size of the VC industry. The description is mainly based on numbers and statistics and is tilted towards information about the U.S. VC industry. We complement the U.S. information with data from European countries and the global VC industry. Venture capital (VC) funds are special-purpose financial intermediaries that raise high-risk capital and invest the capital in developing radical ideas in innovative technology. Where successful, the investment projects in

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which VC funds invest capital become a part of already existing companies by acquisition, or become new companies through IPOs. Some of the ideas were developed in the context of basic research, others came directly from entrepreneurs. In this chapter we aim to put a number on this transition from idea, to successful investment project, to new company. VC funds extend the market portfolio and contribute to increased consumption on a societal level. Comprised of VC funds, institutional investors, and other intermediaries like family offices that provide high risk capital, as well as entrepreneurs that propose investment projects based on radical ideas in innovative technology, the industry includes many different but small actors relative to the actors and volumes on traditional financial market. In this chapter, we discuss data on VC funds and related actors.

2.2 The Structure of VC Funds

VC funds are organized as limited partnerships with a finite and short horizon compared to the infinite horizon of limited liability companies. Figure 2.1 shows a schematic picture of the actors and their relationships that together constitute the VC industry.

In the center is the VC fund, here illustrated by a T-account balance sheet with assets, liabilities, and net worth. Like any limited partnerships,

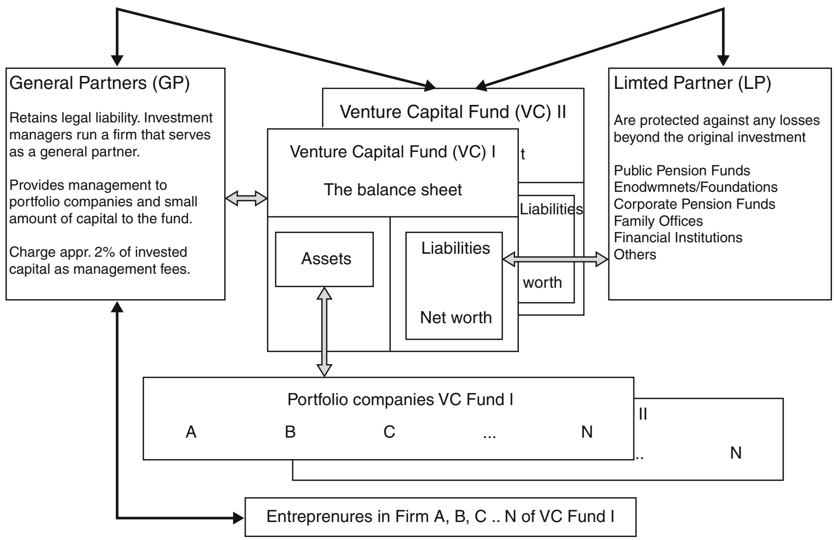

Fig. 2.1 VC fund actors and investment relations

VC funds are comprised of limited partners (LPs) that provide the capital and general partners (GPs) that manage the fund according to a contract between the LPs and the VC fund. The liabilities match the limited and general partners' investments in the fund. The corresponding assets are the holdings in the portfolio companies.

VC funds can be described by the contracts that define the relationships between the LPs, the GP, and the VC fund. The contracts are the small arrows in the picture. These contracts determine the way that VC funds operate. One contract is between the VC fund and the LPs. The LPs agree to commit a certain amount of capital to the VC fund, to be invested in particular types of projects, which are specified in the contract. The GP of the VC fund has the right to call on the capital according to investment needs. A second contract is between the LPs, the VC fund, and the GP. This contract specifies the payments for the GP. In most if not all cases the payment to the GP is comprised of a certain percentage per year of the total capital raised by the VC fund. This payment is called a management fee and it ranges between 1 % and 2 % of the total capital raised by the VC fund. The second component of the payment for the GP is defined as a share of the profits of the VC funds over its life, called 'carried interest' or a 'performance fee'. A common payment is 20 % of the profits, conditional on profits above a certain hurdle rate. We discuss the functionality of the contracts between the LPs and the GP in Chap. 6.

The portfolio companies are the investment objective and vary in size and in stage of development. Usually each VC fund will invest in up to 15 companies. It is between the VC fund and the entrepreneur that we find the third contract or group of contracts. These contracts deal with cash-flow rights and decision rights of the entrepreneurs who are the source for the idea and, in some cases, entreprenuers have proprietary rights and the VC fund that provides the capital. Given the risky nature of the investment projects these contracts are relational and they have a mechanism of renegotiation for both decision rights and cash flow rights. What determines the size and the nature of the assets of VC funds is the contract between the LPs and the VC fund. Given the capital allocation and the specification of the type of investment for which the capital was allocated (e.g. a specific industry like software, or a specific country like China or Finland) the GP has a crucial role in the success or the failure of VC funds. This is so because, given the contract between the LPs and the VC fund, the GP has to select a small number of projects from a large universe of potential investment projects.

It is useful to differentiate between actors who operate organizations as a way to accomplish their goals and the organizations themselves. The organizations (in this case VC funds) are a collection of contracts (the nature of the contracts is discussed in Chap. 6). The actors are people, often managers, who sign contracts that set up the organization. GPs, the decision makers in institutional investors, other providers of capital to VC funds, and entrepreneurs are all people. They may sign contracts that comprise one VC fund, or they may create many VC funds. Decision makers in institutional investors are involved in a number of VC funds. If the institutional investor is large, for instance the New York State Pension Fund, the decision makers probably were involved in setting up a large number of VC funds. Successful GPs may be involved in a number of VC funds. Matrix Partners, a well-established VC firm (a GP), set up nine VC funds and raised a total of $2.4 billion. Some “serial entrepreneurs” were involved in more than one VC fund.

2.3 The Size of VC Funds

2.3.1 The Size of VC Funds in the Global World

Table 2.1 shows the global annual investment and the number of deals made by VC funds in the world in the period from 2008 to 2014. With two exceptions, 2009 (the year of the global financial crisis) and 2014 (where VC funds made some mega-investments) total annual investment was around $50 billion and the number of deals was between 5500 and 6500 per year. Total investment by the VC funds in the world in the years

Table 2.1 Annual investment by VC funds from all countries (Money, # of Deals)

Years	*Total investment ($ billion)*	*Number of deals*
2008	51.2	5500
2009	35.4	4813
2010	46.6	5438
2011	55.9	6040
2012	49.5	6085
2013	53.5	6551
2014	86.7	6507

Source: Pearce (2014)

from 2008 to 2014 and the number of investment projects per year are presented in Table 2.1.

In Table 2.2 we present the geographical distribution of VC funds by geopolitical areas. The table includes invested capital, and investment rounds per area. China and India, two newcomers to the VC world, are getting close to Europe in the amount invested and the number of deals. Israel, a small country, is an exception and should be counted as an extension of the U.S. venture capital industry as almost all the capital invested in VC funds in Israel comes from U.S. institutional investors.

In recent years the venture capital industry has becomemore global. China is now a focal point for many VC funds, both as a source of capital and as an investment target. This was not so five years ago. Yet, most of the venture capital industry and VC funds are in the U.S. Also, while today used worldwide, the investment model of the venture capital industry as a cooperative effort between institutional investors, VC funds, and entrepreneurs was developed and practiced in the U.S. Therefore, we focus in this chapter on the size and the characteristics of the venture capital industry and VC funds in the U.S.

2.3.2 The Size of VC Funds in the U.S.

The data on annual capital investments of VC funds in the U.S shows that the period between 1985 and 2014 can be divided roughly into the following four periods:first, an early-stage between 1985 and 1994, where the annual capital invested in the U.S. were around \$3 billion (Fig. 2.2). Second, in the boom period in the late 1990s the amount grew quickly, reaching \$100 billion in 2000. Third, it went down sharply in the period from 2002 to 2005 and increased to about \$30 billion in 2006. Fourth,

Table 2.2 Geographical distribution of VC funds 2013

Region	*Amount invested (\$ billion)*	*Investment rounds*	*% of activity*
US	33.1	3480	68.2
Europe	7.4	1395	15.3
Canada	1.0	176	2.1
China	3.5	314	7.2
India	1.8	222	3.7
Israel	1.7	166	3.5

Source: Pearce (2014)

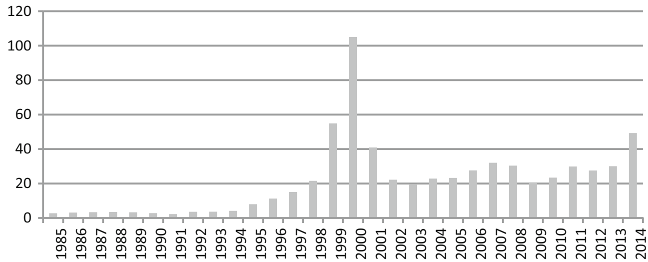

Fig. 2.2 Venture capital investments in the US, between 1985 and 2014 ($ billions). *Source*: NVCA (2015)

Table 2.3 The dimensions of the VC industry in the US 1994 and 2014

	1994	*2014*	*% Change*
Number of VC Firms (GPs)	385	803	108
Number of VC Funds	635	1206	90
Number of professionals	3735	5680	52
Capital under Management ($ billion)	33.2	156.5	371

Source: NVCA (2015)

capital investment declined again during the crisis of 2008–2009. Since 2010 the annual capital investment has been around $25–$30 billion per year. Capital investment went up in 2014 to about $30 similar to the 2001 level of investments. Agmon and Messica (2007) present data that connects the changes in the amounts of capital raised by VC funds in the U.S. to the changes in the price index of NASDAQ. As shown in Fig. 2.2, the year 2000 was an exceptional peak year for VC funds, followed by a sharp decline in capital raised that continued for 13 years.

In Table 2.3 we show the growth over the 20-year period in the number of GPs' firms (sometimes referred to as venture capitalists), the number of active VC funds, the number of professionals employed by the GPs firm and the capital under management by comparing the first and the last year of data. As it is clear from the data presented below the real jump was in capital under management close to five times. What was in 1994 a budding industry became an important part of the inventive process in the U.S.

Capital under management is an outcome of capital raised by VC funds (Table 2.3). VC funds have a horizon of 10–12 years. The capital raised by a VC fund at the time of its establishment is transmitted to the fund as the investment process proceeds. At any given time, the capital commitment of a specific fund is divided into three parts: one, capital invested and returned to the investors (distributed capital), two, capital invested in a company still held by the VC fund (capital under management), and three, callable capital yet to be called by the GP of the VC fund in question (dry powder). Dry powder is about one-half of assets under management. Dry powder is a function of changes in capital commitment. If capital commitment increases more than capital investments, as it did in the years after 2001, dry powder will increase as well.

Although the U.S. venture capital industry and U.S. VC funds grew substantially in the 20 years from 1994 to 2014, it is still a small industry, and VC funds are small financial intermediaries (Fig. 2.2). The closest financial intermediaries to VC funds are private equity (PE) funds. PE funds are also limited partnerships, and are organized in a similar way to VC funds. Most institutional investors classify PE funds and VC funds as alternative investments (AIM). However, PE funds follow a different investment model than VC funds. They invest in existing companies, which are usually based on a specific business model that the GPs of the PE fund think has a potential to increase the value of the target company. According to data published by Perqin in 2014, there were at that point in time about 2200 operating PE funds in the world. They raised $465 billion in 2014, compared to less than $90 billion raised by all VC funds in the world. In 2014, PE funds in the world had more than $3.5 trillion under management, compared to little more than $150 billion in capital under management by U.S. VC funds. Other financial intermediaries like banks are much larger in capital holdings and in the number of institutions and employees than VC funds. As of 2014, Wells Fargo Bank, the largest bank in the U.S. in terms of employees, had 228,000 employees and total assets of $1.7 trillion. The banking sector in the U.S. employed 260,000 loan officers in 2014. U.S. VC funds employed less than 6000 professionals.

2.3.3 The Number and the Nature of the Investment Projects of VC Funds in the U.S.

Investment in radical ideas is a dynamic process. All projects begin as either seed or early-stage. Most VC funds do not invest in seed (that investment is often financed by angel investors) but they do invest in early-stage. It can be said that investment in early-stage is investment in "pure ideas," whereas investment in more advanced stages, known as "expansion" and "later-stage" is investment in development and commercialization. In 2014, the total investment by U.S. VC funds was allocated as follows in number of deals: 2 % to seed investment, 32 % to early-stage investments, 42 % to expansion stage (second and third rounds of investment), and 25 % to later stages. VC funds usually focus on one or two industries at any given point in time (Table 2.4).

In recent years the IT and Life Sciences sectors lead the investments by VC funds. In earlier periods U.S. VC funds focused on other industries, like semiconductors. In Table 2.5 we present data on the investment of VC funds in the U.S. in initial stages and in all investments by industry groups in 2014.

Average investment by U.S. VC funds in 2014 was almost $13.5 million and average initial-stage investments were only $5.1 million (average investment in later stage investments were almost $19 million). This reflects the increasing need of capital for VC backed firms when moving to later stages.

Table 2.4 Venture capital investment by stage (2014) US data

Seed	*Early stage*	*Expansion*	*Later stage*
2 %	32 %	42 %	25 %

Source: NVCA (2015)

Table 2.5 Investment by U.S. VC funds by industry groups and stage of investment in 2014

Industry	*All investments*			*Initial stage*		
	Companies (numbers)	*Deals (numbers)*	*Investment ($ billions)*	*Companies (numbers)*	*Deals (numbers)*	*Investment ($ billions)*
IT	2611	3050	35.7	1059	1059	5.2
Life Sciences	650	827	8.8	174	174	1.2
Non Hi-Tech	404	484	4.8	177	177	0.9
Total	3655	4361	49.3	1410	1410	7.3

Source: NVCA (2015)

Unlike other financial intermediaries, the outcome investments by VC funds are not standard and a number of them receive much attention. The National Venture Capital Association in the U.S. presents the face of the VC industry via a list of well-known new and innovative public companies that were supported by VC investments in their early stages. The list includes names like Microsoft, Starbucks Corporation, eBay, Apple Inc., and Staples. The largest single VC investment in 2014 was in Uber Technologies, Inc. that received two investments of $1.2 billion each in later-stage rounds in June and December.

2.3.4 The Dynamics of U.S. VC Funds

VC funds are temporary financial intermediaries. As limited partnerships, they have a given horizon and by the end of the period specified in the contract between the VC fund and the LPs the fund ceases to exist. GPs are usually organized as limited liabilities firms, in the industry known as VC firms, and they do not have a specific horizon. Most GPs would like to follow their first VC fund with consecutive funds. According to data collected and based on an 8-year horizon 1938 GPs (venture capital firms) raised funds and managed 4957 venture capital funds, for an average of 2.55 VC funds per GP. The number of first-time VC funds is small. In 1994 there were 25 first-time VC funds out of 136 VC funds that raised capital in this year. The comparable numbers for 2014 were 36 first-timers out of 263 VC funds that raised capital in that year. The percentage of first-timers is quite stable at 15–20 per year. Most VC funds are small. In 2014, 538 out of the active 803 GPs manage less than $100 million. Only 31 GPs (4%) manage more than $1 billion.

The total number of active VC funds in the U.S. does not change much (Table 2.6). Some GPs are leaving the industry and new GPs raise new funds, but one-time GPs often turn out to be unsuccessful and they then cannot raise a second VC fund, but the industry as a whole is quite stable.

2.4 The Sources of Capital for U.S. VC Funds

Asset allocation for high-risk investment in VC funds is a crucial part of the venture capital industry. In Table 2.7 we show the contribution of different sources to the capital of VC funds.

Most if not all of the capital invested in VC funds comes from intermediaries that manage money for different types of beneficiaries. The beneficiaries

Table 2.6 The number of VC funds per year and capital raised

Year	*Number of funds*	*Venture Capital ($ million)*
2006	236	31,107.6
2007	235	29,993.7
2008	214	25,054.9
2009	162	16,103.8
2010	176	13,283.6
2011	192	19,080.5
2012	217	19,844.9
2013	208	17,702.0
2014	263	30,711.3

Source: NVCA (2015)

Table 2.7 Sources of capital for U.S. VC funds 2014

Source of capital	*Share of investment in VC funds (%)*
Public Pension Funds	20
Endowments/Foundations	17
Corporate Pension Funds	7
Insurance Companies	7
Family Offices	14
Financial Institutions	13
Others	22

Source: BloombergBusiness (2014)

of pension funds are primarily middle class and working class savers. The beneficiaries of family offices are wealthy families, and the beneficiaries of endowments and foundations are their donors.

In China, India, and the European Union member states, the governments provide capital to VC funds, and in some cases also participate in the management of VC funds. Table 2.8 shows the distribution of sources of capital for European VC funds.

The first four sources in Table 2.7 are institutional investors and together they contribute 51 % of the capital for U.S. VC funds. The comparable number for European VC funds is 32.1 %. There is an interesting mismatchbetween the importance of the capital for the VC funds and the intermediaries that allocate capital for investment in VC funds. Public

Table 2.8 Sources of capital for European VC funds

Source of capital	*Share of investment in VC funds (%)*
Government agencies	30.0
Pension funds	12.3
Financial institutions (Banks, Mutual funds, Fund of funds, Sovereign funds)	11.5
Insurance companies	2.2
Corporate investors	10.7
Endowments, foundations and academic institutions	6.1
Family offices and private individuals	11.2
Other	15.9

Source: EVCA (2015)

pension funds are crucial for VC funds as a source of capital. This is particularly true for small or new VC funds as public pension funds tend to allocate capital to a large number of VC funds, and they are also regarded by other potential investors in VC fund as necessary LPs. But public pension funds allocate 0.5% to 1.6% of their portfolio to VC funds and the effect of this investment on their total portfolio return is very small. The role of pension funds and other institutional investors in the venture capital industry is discussed in Chap. 7.

2.5 Success and Failure in U.S. VC Funds

VC funds invest in risky investment projects. We discuss the specific nature of the risk that VC funds deal with in later chapters. In this section, we show how the inherent risk is expressed in the reported results of U.S. VC funds. In its annual report of 2015, the National Venture Capital Association (NVCA) published information about the outcome of 11,686 companies first funded by U.S. VC funds in the period from 1991 to 2000. Of these companies, 14 % made an exit through an IPO, 33% were acquired by other companies, 18% are known to have failed, and the fate of 35% of the companies is unknown.[1]

Of the companies first funded by VC funds in this period, 47 % made an exit. That seems like a high rate of success. However, the LPs who invest in VC funds measure their return on the total amount invested. Successes have to cover the losses of the 53% of the companies funded by U.S. VC funds that did not make an exit. In Table 2.9 we present data for selected

Table 2.9 Exits by IPOs and acquisitions for selected year

Year	*IPOs (number)*	*Total value at IPOs ($ billion)*	*Acquisition (number)*	*Average value of acquisition ($ billion)*
1994	130	5	84	56
2000	230	25	245	326
2009	10	1	109	113
2014	115	12	459	350

Source: NVCA (2015)

years on VC backed IPOs and acquisitions. The data on the acquisition includes all the acquisitions done in that year, but the average value is based on the acquisitions of that year where the price was known. In 2014 about 30% of the acquired companies reported the price of the acquisition.

The years in Table 2.9 represent four different periods in the history of U.S. VC funds: 1994 is the infancy period of U.S. VC funds, 2000 is the peak of the dot-com bubble, 2008-2009 are the financial crisis years, and 2014 seems to be a beginning of new growth for VC funds.

The aggregate numbers of the successes and failures reported in this section tell only part of the picture. VC funds are looking for exceptional, high-return investments. Examples for exits that brought VC funds extremely large profits are Apple's IPO, Nest's acquisition by Google, Facebook's IPO, and the biggest IPO ever: Alibaba Group's recent IPO at a value of $25 billion. On the other hand, many IPOs, primarily VC-backed biotech companies, end up with modest profits, as do many acquisitions.

2.6 Summary

VC funds are unique financial intermediaries. They are small by any measurement: annual investment, assets under management, number of VC funds, or number of people employed by the venture capital firms, the GPs. Unlike most financial intermediaries that are organized as limited liabilities companies, VC funds are organized as limited partnerships with a relatively short horizon. VC funds also have a unique business model wherein they are looking for the rare early-stage investments that will have exceptionally high profits at the exit and will ultimately develop into companies like Apple, Facebook and Alibaba. Yet, VC funds and the venture capital industry attract a lot of attention in the financial world, among global policy makers, in the world of research, and in the public at large.

Note

1. Companies that were funded for the first time by VC funds before or at 2000 cannot be held by them 14 years later in 2014.

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CHAPTER 3

VC Funds and the Semiconductor Industry: An Illustration

Abstract In this chapter, we provide an example of the role of VC funds in the process of turning ideas into assets that contribute to future consumption. The example gives the reader a concrete illustration of what VC funds actually do. The semiconductor industry was chosen for the example for the following reasons: it is a modern industry based on an idea that precedes the application by about 100 years. Further, it is an industry that affects many industries; for instance, both the automotive industry and new industries like mobile phones. VC funds financed some of the industry leaders at the early stage and contributed to the development of applications by second-generation innovative firms.

Keywords Radical ideas • Radical technologies • Semiconductor industry • Venture capital

3.1 Introduction

The development of the semiconductor industry from an abstract, radical innovative idea to a major industry that changed the patterns of consumption of most people in the world is an excellent illustration of the process from idea to consumption and of the role of VC funds in this process. Discussing a concrete case provides a good overview of the process before we deal with the various facets of the venture capital industry and the VC funds. In an article on the history of semiconductors (Lukasiak &

T. Agmon, S. Sjögren, *Venture Capital and the Inventive Process*,
DOI 10.1057/978-1-137-53660-0_3

Jakubowski, 2010), the authors compare the invention and the development of semiconductors to the invention and the development of the printing press. In both cases the outcome was the creation of general media with an extremely large number of applications. Both inventions were metamorphic and affected almost all aspects of human life. Today the total semiconductor industry counts for a predicted $344.5 billion in total sales (http://www.semiconductors.org/industry_statistics/), a big number but not even close to the sum of total turnover of industries that use semiconductor devices to produce goods and services, especially within the IT and computer sectors, which in turn is a very small part of the total producer and consumer surplus made possible by semiconductor technology.

3.2 The Development of the Idea of Semiconductors

The semiconductor is not an invention and no single individual invented it. The base of the semiconductor industry was the discovery that some material (e.g. silicon, germanium) has unique properties that in some directions have lower resistance than in other directions. The electrical conductivity of a semi-conductive material can be changed by altering temperature (conductivity increases with temperature), or by "doping" it via adding other material. The early work of combining knowledge of electrons and quantum mechanics (electronics) prepared the semiconductor to be developed into diodes and transistors. These are perhaps the two most important inventions necessary for our advancement in data processing, communication, and lighting.

3.2.1 The Early Stages of Semiconductors

Lukasiak and Jakubowski (2010) discussed the history of the semiconductor. The germination period of the idea of semiconductors was long. The term "semiconducting" was used for the first time by Alessandro Volta in 1782. It took 50 years until Michael Faraday came up with the first documented observation of a semiconductor effect. The first quantitative analysis of semiconductors was published by Hittorf in 1851. Photoconductivity in solids was discovered by Wiloughby Smith in 1873. The first working solar cell was constructed by Fritts in 1873. The theory related to semiconductors was developed at an accelerated rate at the beginning of the twentieth century. As the concepts and the theory behind semiconductors were developed, refined devices based on the concepts and theory were designed and built. A number of patents were awarded to such devices. After more than a hundred years since the first documented observation of the semiconductor effect, semiconductors became products. This development would not been possible without simultaneous discoveries in other fields of physics, such as the development of quantum physics and the subsequent understanding of electrons' wave-like behavior in solid-state devices (i.e., transistors).

3.2.2 From Ideas to Products

In the first 50 years of the twentieth century, the idea of semiconductors was turned into a procession of products. Many of these products were built in laboratories and did not have any commercial value per se, but they were steps towards the industry as we know it today. Most if not all of this activity was done by physicists as a part of their research (some of them were awarded the Nobel Prize for their research[1]). The Metal-Oxide-Semiconductor-Field-Effect (MOSFET) transistor was developed as early as 1930. The first germanium point contact transistor was built by Bardeen and Brattain in 1947. The final step that was the forerunner of the current semiconductor industry was the manufacturing of silicon transistors by Gordon Teal. This made it possible to replace the vacuum-tube technique that was both space- and electricity-consuming. In 1958, the first integrated circuit was demonstrated by Kilby, allowing for the distance between each transistor to be minimized. This started the miniaturization of computers that has been exponential since 1970. The number of transistors in an integrated circuit follows the famous Moore's law and doubles every second year, while the size of the transistor is simultaneously minimized with nearly the opposite negative exponential speed. Based on research and development done at the Bell Laboratories in the 1950s, radio transistors have been produced since 1954, and television, radar, and light-emitting diodes (LEDs) have thereafter enriched society.

3.3 From Devices to Commercialized Products: VC Fund Participation in Forming an Industry

In 1955, Schockley, one of the inventors of the modern semiconductor, founded Schockley Semiconductors Laboratory in Santa Clara, CA. He recruited 12 scientists to work with him. Two years later, in 1957, eight of the Schockley team, known as the "Traitorous Eight" left to start their own company using their own savings as the initial investment. The group included Gordon Moore and Robert Noyce who founded Intel ten years later. Their main development was a method of mass-producing silicon transistors. Given the success of the development the young company needed financing. Within the first year, the group was able to convince Fairchild Camera and Instruments Corporation to invest $1.5 million in setting up a new company called Fairchild Semiconductors. The market for semiconductors grew. By 1964, sales reached $1 billion per year. In 1968, Noyce and Moore left Fairchild Semiconductors and established Intel with financing from venture capitalist Arthur Rock who personally invested $10,000 in the company and raised $2.5 million. In 1971, Intel went public with an IPO value of $6.8 million. Intel is today the leading semiconductor company in the world with more than 100,000 employees worldwide and sales of more than $55 billion. The total sales of the semiconductor industry in 2014 were about $344 billion. Two main processes drove the growth of the semiconductor industry: first, a constant and rapid increase in quality combined with a simultaneous decline in price. The second process was the rapid development of applications. The first transistors in the late 1950s were used primarily for radios. Today, semiconductors are the basis for the new world of digital communications.

According to data collected by Paik (2014), 135 early-stage companies (start-ups) in the semiconductor industry were financed by VC funds in the period from 1990 to 1995. The five years between 1990 and 1995 were a fast growth period for the U.S.-based semiconductor industry. Sales tripled from $20 billion to $60 billion per year. Out of the 135 VC-backed start-ups in that time period, 16 went through an IPO, 85 were merged into or acquired by other companies, and 34 failed.[2]

Guzy (2010) provides data on VC backed semiconductor start-ups in this period. Based on data collected by VantagePoint Venture, she reports that the average return on the investment by VC funds on IPOs of VC-backed start-ups was 5.65X, with a median return at the IPO of 2.85X. Three VC-backed semiconductor private companies yielded more than 10X at the IPO. Those are Leadis, Marvell, and PowerDsine. The contribution of VC funds to the development of the semiconductor industry is measured not just by the successes, but by the total number of VC-backed companies in the industry. It is likely that many of the 85 start-ups that were acquired in the period 1995–2000 developed new applications for the industry. They were acquired by more established and bigger companies because they added more uses for semiconductors, reduced production costs of particular products, or both. In doing so, they contributed to higher added value and higher consumers' surplus to society. Even VC-backed companies that fail contribute to society. They do so by identifying which ideas do not work, and, perhaps more importantly, by training engineers and other professionals to work in the innovative processes.

Another important input for our analysis of the economics of VC funds and the contribution of ideas to consumption is government interventions. This will be further discussed in Chap. 6. One such intervention is the strengthening of patent rights. In their study, Hall and Ziedonis (2001) investigate the patent behavior of 95 firms in the semiconductor industry. Between 1979 and 1995, the number of patent approvals per invested dollar was higher in this industry compared to all other industries. Hall & Ziedonis conclude that patent rights may have facilitated the entry of specialized firms and vertical disintegration. However the authors are careful not to posit only positive effects of stronger patent rights. The patent portfolio race which took place in the semiconductor industry at this later stage, may also have had a dampening effect on exchanges of intellectual property. The history of the development of the semiconductor and the devices described above are examples where innovation is essentially cumulative and therefore dependent on the diffusion of knowledge.

3.4 Contribution of Semiconductor to Growth

In a recent trade publication the author states, "*The U.S. semiconductor industry has been a major innovator among all U.S. industries: from 1960 to 2007 it accounts for 30.3% of all economic growth due to innovation in the U.S. and the industry contribution to real economic growth was more than seven times its share in the nominal GDP*" (Parpala, 2014, p. 1). The importance of the semiconductor industry lies in providing new innovative inputs, as well as in producing intermediate goods that allow a number of new industries to grow. Further, semiconductors make old industries more efficient and to provide new features, and to provide more advanced inputs at lower prices every year. In Table 3.1, we show the proportion of the output of the semiconductor industry that was bought by different users of semiconductors divided into sectors. The data shows that the computer and the communication sectors are the major buyers of the output of the semiconductor industry. That output is an intermediate product for final goods and services.

Table 3.1 Value of semiconductors consumed worldwide by end use sector 1999, and 2013

Sector	*Share of total consumption (in %)*	
	1999	*2013*
Computers	50	34
Communication	21	32.5
Consumer	14	14.3
Industrial & Governments	9	9.7
Auto	6	9.5

Source: Aizcorbe (2002), Semiconductor Industry Association (2014)

Over the 14-year period between 1999 and 2013, a long period in terms of the semiconductor industry, the share of communication uses became equivalent in importance to the uses in the computer sector. The share of the automotive sector rose by 50 % between 1999 and 2013. At the same time, the sales of the semiconductor industry grew substantially. In 1999 the global market size was $135 billion, half of it in the U.S. In 2013, the market grew to more than $300 billion, half of it in the Asia Pacific region.

Due to rapid technological changes and increases in quality, it is not simple to measure the changes in price of semiconductors. Yet, there is a broad agreement that prices of semiconductors are declining rapidly and that the price reduction brings about a reduction in relative prices of important categories of other products. According to a study by Aizcorbe, Oliner, and Sichel (2008), the prices of integrated circuits (IC) fell by an average of 36 % per year in the period from 1993 to 1999. Most of the price decline was due to technological innovation and increased productivity. Some of the decline was associated with a decline in the monopolistic power of the leaders in the industry. The decline in the price of semiconductors was translated to a decline in the relative prices of the goods produced by sectors that use semiconductors as important inputs. In the period from 1991 to 1999 lower prices of semiconductors contributed to 16–23 % of the decline in the price of computers, to 6–10 % of the decline in the prices of communication devices, and to 4–6 % of the decline in the prices of consumers' audio products. This trend continues into the twenty-first century where industry sources estimates that the annual cost per function continues to decline at a rate of 35 % per year.

Successful development and commercialization of radical ideas in technology generates three types of benefits: economic rents to the developers and the financiers of the successful ideas, externalities to industries that use the developed idea or its applications, and an increase in current and future consumption that in turn increases consumers' surplus in the society as a whole. The first type of benefits comes first, the second benefits takes longer, and the extension of consumption possibilities leading to the consumers' surplus is accrued over a long time.

As an illustration of how benefits are generated and distributed, consider the case of Intel Corporation and the semiconductor industry as a whole. Intel Corporation was the first new generation semiconductor company (Schockley Semiconductors Laboratory was more of a research organization and Fairchild Semiconductor was an extension of an existing company). Intel Corporation was founded in 1968 with an investment of $2.5 million. The company went public in 1971 at a value of $6.8 million. The initial investors as well as the founders (the entrepreneurs) of Intel received a substantial producers' surplus relative to the original investment. The total increase in the value of Intel between 1968 and 1971 was $4.3 million (a cash-on-cash return of 2.72X). As we have shown earlier in the chapter, the semiconductor industry brought about a decline in the relative prices of important sectors in the U.S. economy, particularly computers and communication. As the market for computers and communication devices is not perfect, some of the benefits of the decline in the price of semiconductors went to increased return on factors of production like capital and labor in the industries affected by the semiconductor industry. The main contribution of the semiconductor industry is to consumers' surplus. If the contribution of the semiconductor industry to the value added of the information industry is expressed by a 10 % increase in its value, and that the information sector is about 5 % of the U.S. GDP of $16.77 trillion, the added contribution of the semiconductor industry is large by any number. The semiconductor industry contributes to welfare by providing efficient inputs to many industries outside the information industry. The economic rent to the successful developers and financiers of the semiconductor industry like Noyce, Moore, and Rock is easily observed and people can relate to it. The externalities to other industries and the increase in current and future consumption is broadly spread and is hard to measure. The real contribution of the semiconductor industry is in the externalities and in the added consumers' surplus, but the potential high return (both financial and otherwise) to a small number of individuals, entrepreneurs, and financiers alike is what motivates the process as a whole.

3.5 Summary: The Role of VC Funds in the Semiconductor Industry

The development of the semiconductor industry provides a good example of the long process of turning a radical innovative idea into a large new industry that develops and supports the new information sector and contributes to many other industries. Producers' surpluses to those involved in the development process and consumers' surplus to consumers at large were generated. VC funds took part in the development and commercialization of the new industry by providing early-stage financing and related services. A well-known example is the contribution of VC financing to Intel. When Intel was founded in 1968, VC funds were at the embryonic stage. The initial financing was organized by Arthur Rock who acted as a GP (including a small personal participation). As the industry developed, VC funds took part in its financing. In a study discussing the contribution of VC funds in the silicon valley to the development of the semiconductor industry Ferary and Granovetter (2009) state, "*The presence of VC funds in an innovative cluster opens specific potential interactions with other agents in which VC funds have a specific function.*" (p. 327). As the semiconductor industry established itself, VC funds finance the development of ideas that were the basis for the second generation of companies in the semiconductor industry.

Notes

1. The list of Nobel laureates in physics related to semiconductor and transistor related development is long; http://www.nobelprize.org/educational/physics
2. A large part of this activity took place in Silicon Valley, and it was here the silicon-based integrated circuit, the microprocessor, and the microcomputer, among other key technologies, were developed. A third of all VC investments during the 1990 was invested in Silicon Valley located start-ups.

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CHAPTER 4

A Macro Perspective on the Unique Role of VC Funds in the Process from Ideas to Growth

Abstract The ideas-led growth model is the macroeconomic framework that describes the inventive process in which VC funds operate. The connection between ideas and growth, and the role of radical ideas within that connection, are discussed in this chapter. As was illustrated in Chap. 3, it takes a long time to move from an idea to concrete products, services, and production technologies that affect consumption. VC funds take a small but important role in this process. VC funds operate in what is defined in economic growth theory as the "technology push" within different technology trajectories in different periods. GPs of VC funds select radical ideas "pushed" by innovators, scientists, and entrepreneurs and turn them into firms.

Keywords Radical ideas economic consumption • Technological change

4.1 Introduction

Over most of the documented history of the Western world, until the last decade of the eighteenth century there was no growth of consumption per capita. This situation has changed radically in the last two and a half centuries, where the rate of growth of consumption per capita grew even as there was a substantial increase in the number of people in the world

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(Maddison, 1995). The most important growth drivers in this period were innovative ideas in technology. Not only did consumption per capita increase but the quality of life increased as well. The consumption basket has expanded in all facets, from transportation, to healthcare, to communication, to food products, to clothing, and to the many other goods and services. The change in total consumption and in the components of the consumption basket had far reaching social and cultural changes as well. All this is the result of innovative ideas in technology. Most of the changes in consumption affect the Western world, particularly the U.S. and the E.U. countries.

Most of the growth in the world is a result of incremental innovation by existing firms. Incremental innovation improves the quality and reduces prices of existing goods and services. A parallel process of radical innovation is a small but important part of the process that has driven economic growth since the beginning of the eighteenth century. The development of the semiconductor industry, discussed in Chap. 2, is an example of radical innovation and its impact on economic growth.

4.2 The Connection Between Ideas and Growth

The special role of ideas in economic growth is discussed by Jones (2005). Jones has extended the classic Solow growth model and the Romer (1990) models. The main two contributions of the ideas-led growth model as discussed by Jones are as follows: first, to place innovative ideas in technology as important factors of production, and second, to show that given the special nature of ideas, growth depends on government intervention. Ideas are different factors of production than labor and capital. In what Jones calls "The Ideas Diagram" he describes the specific characteristics of ideas, and shows the links between ideas, non-rivalry of goods, increasing returns to scale, and competitive equilibrium.

The two specific features of innovative ideas as growth drivers are non-rivalry and increasing return to scale, where increasing return to scale is measured by the number of applications (uses) per idea. Non-rivalry means that once an innovative technology idea proves useful many can use it and develop it to many applications. The repeated use does not "waste" the idea. Technically that means that the marginal (alternative) cost of using a specific idea for one more use is zero. If the idea is useful and contributes to the production of more goods with zero marginal cost, then more applications will increase the return of the idea. Hence, ideas have increasing return to scale. As Jones shows in such a model there is a problem. Labor and capital will be paid their alternative costs, and the ideas will be considered a free factor and not be paid. This is not a tenable situation, as there is a need to invest time, labor, and capital to generate, develop, test, and commercialize ideas so that that they become useful. To encourage innovative technology ideas, high risk must be compensated by high return in case of success. Non-rivalry of ideas means that it is easy to copy an idea-based innovation once it is successful.

The aggregate macroeconomic model presented and discussed by Jones has two important features: the first is the relationship between ideas and economic growth. The generation and the development of innovative ideas in technology and management over time is also known as the inventive process. The inventive process and its relation to growth is supported by data over the last 200 years and a large amount of supportive research in economics, economic history, and the development of technology. Measured in 1990 U.S. dollars, the GDP per capita in the U.S. grew substantially through the twentieth century. Measured in 1990 US dollars, the GDP per capita was $2500 in 1900, $10,000 in 1960 and $25,000 in 2000. The second feature of the ideas-led growth model is that a necessary condition for the inventive process is government intervention. The need for government intervention in order to promote a higher rate of growth was recognized early as is evidenced by the clause in the U.S. Constitution that allows a monopoly, if such a monopoly is needed for economic progress. Article 1, Section 8 of the U.S. Constitution empowers the Congress "*To promote the Progress of Science and useful Arts by securing for Limited Times to Authors and Inventors the exclusive Rights to their respective Writings and Discoveries*". The cost of government intervention is small relative to the high rate of growth of consumption per capita since the beginning of the nineteenth century. Unlike other cases of imperfect markets, the imperfection and the resulting monopoly power in this case is not a case of market failure. It is a planned market intervention. It is the way to maximize welfare over time (the way in which governments intervene in the market is discussed in Chap. 5).

Jones relates the generation process of ideas to the proportion of researchers out of the working force. This is sufficient for his macroeconomic approach. In reality, the process from an idea to increase in per capita consumption is complex. Many people and organizations are involved. Parts of the process are funded directly by the government in the form of funded research. Other parts are funded by donors, and still other parts are financed by the business sector. The U.S. invests about 2.5% of its GDP in research and development. This amount can be used as an estimate for the national resources allocated for generating developing and commercializing innovative ideas in technology and management. In 2013, the GDP of the U.S. was about $17 trillion U.S. dollars of this. 2.5% is $425 billion. According to the R&D statistics in the U.S. this amount is divided into basic research (20%), development (60%) and application (20%). Most if not all of basic research is funded by the government and by donors and foundations. Most of the development and the applications are financed by the business sector, and much of this financing comes through the capital markets.

The ideas-led growth model developed by Jones is conceptual and abstract. Ideas often led to very tangible results that are expressed in the variety and the cost of goods and services that most of us consume on a daily basis. A major example of the growth implications of radical innovative ideas in technology is the history of silicon and the developments of its uses. Silicon is a common material on Earth (and used not only for the semiconductor development discussed in Chap. 3). The development of goods based on silicon goes back in history. The ancient Romans were the first to produce glass and ceramics out of silicates. At the beginning of the inventive period in the Western world in the nineteenth century, pure silicon was synthesized (Berzilius, a Swedish researcher, was the first to prepare elemental silicon in 1823, and in 1866 Alfred Nobel mixed nitroglycerin with silicon to produce dynamite). Early in the twentieth century, silicon was transformed into polymers that were used to coat and impregnate glass and to produce rubber like materials and adhesives (Neil Armstrong stepped on the moon in silicon boots). In the second half of the twentieth century, silicon was an important material in the development of semiconductors, in medicine, and in many other fields. The combination of new innovative radical ideas with silicon is expected to bring about more growth from new technologies like photonics, nanotechnology and plasma. What gives silicon more and more value and makes it a growing part in the consumption of people is innovative ideas in technology.

4.3 The Role of Radical Ideas in the Growth Process

In the Jones model of ideas-led growth, all ideas are treated the same way and research-based innovation is the engine for growth. In the real world there are many different types of innovation. Many individuals, institutions, government agencies and business firms are involved in innovation. A relevant distinction for our purposes is the difference between incremental innovation and radical innovation. Incremental innovation deals primarily with improving existing production processes, goods and services. Incremental innovation is relatively simple: it is a systematic process, and for most part it is done within R&D divisions as a part of the management process of incumbent firms. Radical innovation deals with new production processes, goods, and services. It is unstructured, and it requires entrepreneurial individuals and organizations. The idea of the internal combustion engine and its implementation in the automobile is an example of radical innovation; contrastingly, the change to robotic gears in cars is an example of incremental innovation.

The distinction between different types of ideas is a subject of much research. There is a whole body of literature in economics and management on incremental and radical innovation (sometimes referred to as evolutionary and revolutionary innovation). Garcia and Calantone (2002) provide a thorough literature review of the typology of innovation and the terminology of innovativeness. Norman and Verganti (2012) discuss the difference and the relations between radical (revolutionary) and incremental (evolutionary) innovation. They define incremental innovation as changes in the design that lead to improvements of existing objects and processes. Radical innovation changes either the technology, or the meaning of goods, services and technology processes. There is a basic difference in the risk of incremental innovation and the risk of radical innovation. In probabilistic terms, the difference is between risks within a known distribution of probable results to a risk of not knowing. This type of risk and uncertainty is discussed in the literature under the term “ambiguity” (e.g. Epstein & Ji, 2014).

4.4 Incumbents and VC-Backed New Entrants

In the following section we focus on radical innovation. Schumpeter (1934) coined the term “creative destruction” to describe radical innovation as a situation where new technology replaces (destroys) the current technology. Arrow (1962) discusses similar process under the heading of “drastic innovation”. Successful radical innovative ideas in technology and management may replace a product that now is the standard in the market, or they may replace a production technology with another new approach. The process of replacing incumbent technology is risky and it may take a long time. It involves technological and commercialization issues as well as the resistance of the incumbents to new, radical ideas. Fudenberg and Tirole (1984) discuss the way in which monopoly rents are moving from incumbents to new entrants. Even when the incumbents expect new and radical changes in the technology, they are not adept at developing it and therefore they prefer to try and prevent the radical new ideas from becoming the new standard. The difficulties of incumbents in adapting to radical changes are discussed in the management literature. Christensen and Rosenbloom (1995) show that "attackers" have the upper hand in developing and commercializing new radical technologies. This is because the "attackers" have no commitments to current stakeholders that may not benefit from the introduction of radical innovation. An example is the dairy industry. Pasteurization is a central process in the production of dairy products. For a number of years there has been a competing process to traditional pasteurization, based on nanotechnology. Many argue that the new process is better and more efficient, yet the dairy industry continues to resist the change (Ramsden, 2013). Given the resistance of incumbents to radical innovation, and the large potential of radical innovative ideas in technology if successful, there is a need for new coordination between a developer of ideas, a manager of the process of development testing and commercialization, and a financier of radical ideas. One way for an incumbent to resist developing new radical products is to avoid buying the idea from the entrepreneur, or to buy it and then not develop it. This is possible in a monopolistic market with one incumbent. In an oligopolistic market, where incumbents are threatened by losses in assets in place if a rival incumbent buys and develops the new technology, the incumbents can either choose to bid against each other or not start the bidding process at all in a tacit collusion. If you outbid your rival incumbent, the price will not stop at the value of the idea, but rather increase to cover the loss in the rival incumbent's existing assets. Whenever the bidding process starts, the existing firms will have a race to the bottom. No actor is thus willing to start the bidding process and the idea will not be developed. Norbäck and Persson (2009) show that in such as case the presence of a venture capitalist the price of new ideas increases. A venture capitalist is always willing to start the bidding process. Agmon, Gangopadhyay, and Sjögren (2014) show that patent trusts, which share the cost of protecting themselves from the development of new technologies by banding together to buy radical ideas from entrepreneurs, actually can be welfare enhancing. Once they have bought the idea by outbidding new entrants willing to pay the full value of the idea, it is in the best interest of the incumbents to develop and commercialize the idea.

4.5 The Generation and the Development of Radical Ideas in Technology

Successful radical innovative ideas are specific and their growth consequences are expressed in flows of goods and services and in actual price reductions in the market. The radical change in economic growth since the end of the eighteenth century is explained by a small number of life-changing concrete innovations like steam power, electric power, the telephone, and the internal combustion engine. These major ideas (inventions) have changed the life of all the people in the world. The changes in the quality of life came through the introduction of infrastructure services like indoor plumbing, running water, and in-house electric power, as well as transportation, telephone services, and the Internet. They also came through appliances like washing machines[1] and air conditioners, and through cars and jet planes. Gordon (2012) describes the growth that the world has enjoyed since the end of the eighteenth century as a result of three industrial revolutions, each of which centers on an initial paradigm-changing, metamorphic innovative idea in technology. The first industrial revolution took place in the period from 1750 to 1830 with the inventions of the steam engine, railroads, and cotton spinning machines. The second industrial revolution took place in the period from 1870 to 1900 with the invention of available and useful electric power, the internal combustion engine, and running water (combined with indoor plumbing). The second industrial revolution is still present in many aspects of our daily life like cars, air-conditioning, refrigeration, artificial light, and many of the technologies at the base of most of what we consume. The third industrial revolution took place in the period from 1960 to 1990 with the invention of computers and the Internet. The third industrial revolution is still with us. The number of applications of the Internet is increasing in a rapid pace. Computers are everywhere and affect far-away fields like healthcare, agriculture, communication, and industrial production.

Radical ideas begin in the minds of people and they are often connected to particular individuals. In the early part of the inventive process that has created accelerated growth in the Western developed countries, a small group of individuals made substantial changes to society. In the 1880s three individuals, Thomas Edison, Charles Brush, and Werner von

Siemens were the first to design and build local direct current (DC) electric power devices (Edison personally designed and sold the Long-Legged Mary Ann, an early DC dynamo) Financing radical ideas was done by individuals as well. Edison established his own company, Edison General Electric Company, in 1890. In 1892, he and his major competitor Coffin of Lynn, Massachusetts got together and started the General Electric Company. As we will see in later chapters, radical innovative ideas are still generated by individuals or small groups of individuals and they are financed outside the main stream of the capital market.

A major part of ideas-led growth is the development of new industries. The telephone industry and the electric power industries are two major examples of new industries that were developed at the end of the nineteenth century and at the beginning of the twentieth century. These two industrie contributed significantly to the growth process. The new industries of the nineteenth century were developed from radical innovative ideas of individuals that were financed by small groups of other wealthy individuals. Radical innovative ideas today are often initiated by teams of researchers in universities and research laboratories. Their research is often funded by the government, but the need for an intermediary to bridge the distance between radical innovative ideas and actual production still exits. The biomed industry, the scanning industry, and the application of Internet to various devices (called the "Internet of Things") are examples of new industries that were developed with the help of VC funds.

4.6 The VC Funds as a Part of the Technology "Trajectory"

The annual investment of U.S. VC funds in 2013 was about $20 billion, which represents a little less than 10% of the investment in the development of ideas, which is where VC funds are located in the ideas chain. Although it is small, investment by VC funds is important because it provides a link between radical innovative ideas that often begin with research and consumption of goods and services. Dosi (1982) discusses two alternative models that explain the relationship between technological change and economic growth: "demand pull" and "technology push". A possible interpretation of the analysis developed by Dosi is to relate "demand pull" technological changes to incremental innovation and "technology push" changes to radical innovation. VC funds are part of the "technology push". VC funds are part of the technology push process that begins with what Kuhn (1962) defines as "puzzle solving activity" and ends with concrete products made possible by investment in radical innovative ideas in technology.

Radical innovative ideas at the beginning of the twenty-first century are different than what they were in the second half of the nineteenth century. It takes many more people, more time, and more resources to move from a radical idea to actual production, but the nature of the process has not changed. Dosi (1982) defines the relationship of technological changes to economic growth as taking place within a "technological trajectory". He defines it as, *"a cluster of possible technological directions whose outer boundaries are defined by the nature of the paradigm itself"* Ibid, p. 154. The role of VC funds within a new technological trajectory is comprised of three parts: selecting radical ideas with growth potential, providing finance and management services to the selected ideas, and transferring successful radical ideas after initial development and commercialization to the business sector through IPOs or acquisitions (exits).

A recent example for the role of VC funds in this context is Nest. Nest was established in 2010 by Fadell and Rogers, two ex-Apple engineers. Their early stage operations were financed by two VC funds: Kleiner, Perkins, Caufield & Byer and Shasta. Nest is an example of a start-up that is an application of the general concept of the Internet applied to what is called the "Internet of Things". If successful the "Internet of Things" will change many industries that provide products for the home, such as home appliances. Nest's specific application was to make "unloved products" in the home more attractive by making them a part of an Internet system. As of today Nest has produced only one product: a smart home thermostat. In January 2014, Nest was acquired by Google for $3.2 billion. The acquisition price reflects estimated potential of the radical idea developed by Nest to be the standard of the future. If successful the "Internet of Things" will contribute substantially to economic growth after 2025. The two VC funds that invested at the early stage of Nest provide a crucial link in the process of making an idea into a future economic growth. Another example of the role of VC funds in developing radical ideas is the acquisition of Waze by Google in 2013 for $1.3 billion. Waze, an Israeli start-up, developed and tested a crowd-sourced application for free driving directions based on information provided by the users of the application. Waze was established in 2008 by three Israeli entrepreneurs. It was financed at the early stage by two VC funds, Magma and Vertex. Two additional VC funds, Blue Run Ventures and Qualcomm Ventures, joined the second round of financing. Waze today is an important part of the consumption of many people in the world and its service contributes to the welfare of its users. Without the intermediary role of VC funds Waze might not be available to consumers today.

4.7 Summary

The focus of this chapter is less on VC funds as such, and is more concerned with the context in which VC funds operate. Ideas-led growth is the reason that VC funds exist. From a societal, macroeconomic view the only reason for VC funds to exist is their ability to facilitate the process from ideas to growth—a long-term economic and social process that has shaped our world for the last two hundred years and is likely to do so in the future.

Note

1. The washing machine has been considered as perhaps the most important innovation for changes in our daily life. It freed more time than other innovations (compare TV that absorbs time) for doing other activities and has had a special gender effect increasing the possibilities for women to spend time on other activities (see Hans Rosling at https://www.ted.com/talks/hans_rosling_and_the_magic_washing_machine for an amusing presentation on statistics on the "washing line" and world development).

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CHAPTER 5

Government Intervention to Promote Radical Ideas and VC Funds as a Functional Form to Facilitate Their Financing

Abstract Firms are defined by their nexus of contracts. Although VC funds are financial intermediaries, their structure and their mode of operations is determined by a nexus of explicit and implicit contracts between those who provide the necessary inputs to VC funds. Like any other firms, VC funds are comprised of assets and liabilities. The liabilities of VC funds are equity transferred from savers through LPs; the assets are investments in young companies based on radical ideas in technology. Three basic contracts define how much capital VC funds invest, in what type of projects they invest, and how the return on the investment is allocated between entrepreneurs, GPs and LPs. These three contracts are the contract that defines the VC fund, the contract between the VC fund (the GP) and the entrepreneurs, and the contract between the LPs and the GP.

Keywords Explicit and Implicit Contracts • temporary monopoly • IP laws

5.1 Introduction

Governments intervene in markets for three main reasons: first, to change the income and wealth distribution, second, to correct market failures that reduce welfare, and third, to promote specific forms of future growth that will be lost without government intervention. Ideas-led growth is a process that requires government intervention. In Fig. 5.1 we use the concept

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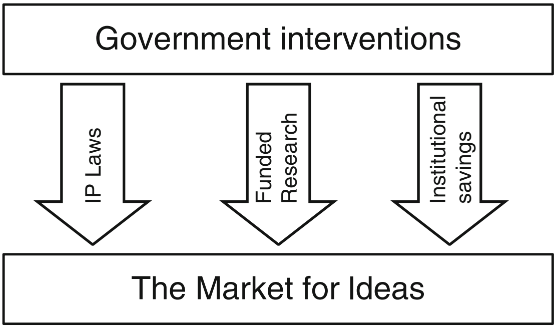

Fig. 5.1 Government interventions for promoting radical innovations in the market for ideas

of the "market for ideas" to summarize the markets and actors involved in developing, transferring and commercializing ideas into products.

5.2 Types of Government Interventions

Merton and Bodie (2005) develop what they have defined as functional and structural finance (FSF). FSF describes situations where due to specific transaction costs, behavioral considerations, and other such market imperfections atomistic markets cannot provide the necessary financing solutions. In such cases, institutions become an endogenous part of financing solutions. The case of financing investment in the development and early commercialization of radical ideas in technology is such a case. As was discussed in Chap. 4, and is discussed in more detail in this chapter, the development of radical ideas requires government intervention in three ways. First, the developers and financiers of radical ideas must be allowed to appropriate some of the benefits of the idea to themselves if the idea turns out to be successful. As is discussed in Sect. 5.5 below, this is done by granting successful developers and financiers of radical ideas temporary monopoly power.

Second, government must subsidize the generation of radical ideas through funded research. This will be discussed in Sect. 5.3. Third, government must make it easy for middle class savers to allocate small percentage of their savings to finance high-risk radical ideas through institutional investors like pension funds and endowments (Sect. 5.4). In addition, radical ideas are based on proprietary information. The idiosyncrasies of radical ideas make them unfit to be traded in arm's length atomistic markets with free and full information available to all participants. Yet, the development of radical ideas in technology and the amount needed for their development requires access to the biggest part of the capital market. In the U.S., this is the market of institutional savings. The growth of VC funds since 1994 is the solution developed by the market to allow institutions like pension funds, endowments and other managers of savings like family offices to create VC funds as specific financial intermediaries to finance the transition from ideas to "normal" firms. Once an exit occurs, financing moves from the functional and structural institutional arrangement to the market.

5.3 Why Government-Funded Research Is Necessary to Promote the Generation of Ideas: The Public-Good Characteristics of Radical Ideas

There is a common saying defining the non-rivalrous nature of ideas as a public good as, "*If you have one apple and I have one apple and we exchange these apples then you and I still each have one apple. But if you have an idea and I have an idea and we exchange these ideas, then each of us will have two ideas*". A more common definition of a public good in economics is that it does not diminish in consumption. All of this means that the alternative cost of ideas is zero. As was discussed in Chap. 4 in the context of Jones, if radical innovative ideas in technology were to become public goods, no one will be willing to invest time, effort, and capital to develop such ideas as an economic investment. One way to resolve the issue of public good is to have the government itself invest in public goods. For many years, governments have invested in and supplied public goods. Defense is a prime example of a good that is supplied by local authorities and paid for by taxes collected from the public. Fireworks provide another, marginal example. In recent years there has been a move for the participation of the private sector in the production of public goods. Besley and Ghatak (2001) discuss the process of production of public goods by private sector firms. The main implication of their study is that in case of public goods (non-rivalrous and non-excludable) the party with the higher valuation should be the owner.

Radical ideas in technology are public goods in the sense that they are non-rivalrous and non-excludable. Often radical ideas that developed for one purpose find their way to other related and non-related industries. As we saw in Chap. 3, semiconductors were developed primarily within the IT and communications sectors, but soon found their way to the automotive industry. Broadband is regarded as public good and is comparable to electricity and running water. Yet as Honig (2012) points out, broadband in the U.S. is the outcome of private investment. In 2008–2012 broadband providers invested more than $250 million and they own the system.

Radical ideas in technology are not coming out of nowhere. In the early days of the inventive process individuals who were not related to any research institutions were responsible for many inventions. Addison, Morse, and Bell are well-known names, but there were others like Jacob Dyson who invented a revolutionary drill and other individuals who contributed much to the development of radical ideas that changed the world in the second half of the nineteenth century. In the second part of the twentieth century and the beginning of the twenty-first century, basic research became a large industry, funded in most cases by the government. The National Institute of Health (NIH) is a major funder of ideas. The NIH invests about $30 billion annually. In 2012 NIH supported about 400,000 jobs in research. In 2014, the U.S. government invested $60 billion in non-defense research. Governments, globally, follow different strategies on how to support and spur technological innovation. The amount spent on R&D is of significant size (Fig. 5.2) and for some European countries (and South Korea) it is close to 1 % of GNP.

Radical ideas in technology are assets in the sense that given an investment they generate probable cash flows in the future. The value of the idea at the day of the investment by VC funds reflects the current risk-adjusted value of the future cash flows, given the probability distribution of future cash flows. In his book "Economic Dynamics" Baumol (1970) argues that although the value of an asset is the risk- adjusted present value of the future cash flows, the cash flows and their probability distribution depends on investment decisions that were made in the past. Therefore, the past history of an asset affects its current value. It follows that public investment in basic research affects the value of radical ideas in technology. VC funds consider the potential of the project if successful. The value of the investment in the project, an asset based on radical ideas, depends on future cash flows, but the future cash flows emanate from earlier work that were done in a framework of funded research. The current investments by

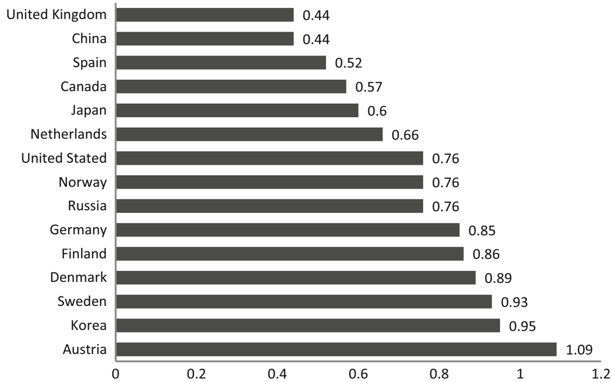

Fig. 5.2 Government spending on R&D as percentage of GNP, 2013, for some OECD and non-OECD members. *Source*: OECD.Stat

VC funds in healthcare benefited from earlier funded research by the NIH and other research organizations.

In 1945, Vannevar Bush wrote a letter to the president titled, “Science – the Endless Frontier,” asking, “what can the Government do now and in the future to aid research activities by public and private organizations?” (https://www.nsf.gov/od/lpa/nsf50/vbush1945.htm). Federal support of American academic institutions increased rapidly up to 1970. This increase was accompanied by less industrial support for research funding (Atkinson & Blanpied, 2008). Government- supported inventions were made available via nonexclusive licenses, resulting in less incentives for companies to co-fund projects in universities. The Bah-Dole act (Patent and Trademark Law Amendments Act, 1980) allows universities to claim legal rights of their inventions, even if those inventions were funded by government support. Since the introduction of this act, universities have developed technology transfer offices (TTO) with the express purpose of commercializing innovations. Industry funding of R&D at universities and colleges increased from a level of $400 million per year in 1980 to $2000 million per year in 2005 (Litan, Mitchell, & Reedy, 2007). The commercialization activity within university transfer offices has also increased the number of VC-backed spin-offs where the TTO is part of the selection process, as well as part of early-stage nurturing (Wright, Lockett, Clarysse, & Binks, 2006).

5.4 Temporary and Contestable Monopoly: Government Intervention Through IP Laws

5.4.1 Competition, Monopoly and IP Laws

Competition is considered the most important factor in productivity, growth, and consumers' welfare. In the U.S. and in other Western countries competition is equated to liberty. Therefore, the well-established intervention of the U.S. government, as well as many other governments in the market for innovation through intellectual property (IP) laws has raised much scholarly, legal and policy discussion. In the introduction to a book titled, "Creation without Restraint: Promoting Liberty and Rivalry in Innovation", Bohannan and Hovenkamp (2012) state, "*The Constitution (of the U.S.) IP clause, with its requirement that patent and copyright law 'promote the progress' of their fields by creating rights for 'limited times', establishes a rationale for IP that is based on economic incentives rather than some alternative theory such as natural rights" (Ibid p1)*. Later in the introduction they say, "*An innovation policy based on private incentives requires balancing of two offsetting rights. One is the right to compete by innovating new things; the other is the right to appropriate part of the value of innovation's results" (p.2)*. The same principle is discussed in the economic literature. Darby and Zucker (2006) state, "*The world's leading economies are characterized by national innovation systems which encourage development of embryonic inventions into successful commercial innovations that reduce costs or improve the qualities of existing products or create new entirely new products. Innovation is driven by appropriable opportunity*" (p.1).

Competition and monopoly are two important and necessary conditions for the generation, testing, and development of innovative ideas in technology. Competition is a key concept in the legal structure of the US, the EU and other countries. Comparing the legal expression of the concept of competition in the US as expressed by the Sherman Act to that of the EU as it is expressed by the Treaty of Rome and related agreements (Graham & Richardson, 1997) the U.S. competition relates to a basic idea of individual liberty and the EU competition is seen as a necessary condition in the process of European integration. Monopoly is seen as a necessity to overcome the public-good nature of ideas and to create an incentive to invest time, effort, and capital in the development and commercialization of ideas. Schumpeter (1942) argued that monopoly is necessary to develop radical destructive ideas. Arrow (1962) has argued that the monopoly power should be given to new entrants if successful, as the incumbent monopolistic industry is less likely to innovate. The monopolists would not feel the need to carry the fixed cost and the risk of new innovation. Therefore, only the competitive pressure of new entrants will bring innovation. The new entrants should get monopoly power if they are successful, thus justifying the high risk of investing in new ideas. This is a dynamic process. Successful radical ideas are turned into innovative technology through exits to new incumbents and these incumbents are in turn challenged by new entrants. The short-term horizon of VC funds as limited partnerships makes them an efficient vehicle to develop challenging radical ideas that if successful will replace incumbents. This is so as the limited horizon prevents VC funds to become incumbents. Microsoft and Intel are examples for VC backed young companies that over time developed into incumbents. The potential of gaining monopoly rents for investments in radical ideas in technology is a driving force for entrepreneurs and GPs alike. It is also part of the motivation of institutional investors and other managers of savings which allocate capital to VC funds. Competition among GPs is also an important factor in investment decisions by VC funds. The contract between LPs and GPs in VC funds drives GPs to try and generate high profits. The success of one VC fund in a given investment makes other VC funds try harder to replicate this success. One way to do that is to find a better radical idea that will replace the now successful one.

A similar approach is found in the legal literature on IP laws**.** In an article titled, "A New Balance Between IP and Antitrust" (Lemley, 2007) the author summarizes his view as follows: "*The cyclical nature of the IP-antitrust interface is understandable, given the fact that the interests that drive the strengthening of one law push toward weakening the other*" (p. 17). But it is not desirable. The goal of both IP and antitrust as regulatory policies should be to balance the need to incentivize innovation against the need for robust competition.

The practice is a synthesis between competition and monopoly. IP laws grant a temporary and contestable monopoly through patents. On the legal side, a patent is defined as "*a limited monopoly granted by the government for the term period of the patent*" (US Legal Definitions, p. 1). On the financial side, the limited time horizon of VC funds and the incentives of GPs to search for the next big success keep patent-based monopolies short-term and constantly contestable.

There is also the fundamental idea that IP systems should promote the diffusion of new technology by encouraging inventors to share their inventions. What is called the patent puzzle (Hall & Harhoff, 2012) is that too strong IP laws, instead of supporting the possibility of combining innovations, impede diffusion. Under strong IP laws, companies have developed IP strategies that directly counteract the idea of openness and are used to extract monopoly rents. Lerner (2002) finds evidence that wealthier countries and countries with democratic institutions have stronger patent protection. He also finds that legal tradition affects the patent regime. What is also pointed out in the study by Lerner is that the patent regimes are shaped by those actors that are in power. Pushed forward by countries with strong patent regimes, global agreements have been introduced. The PCT (Patent Cooperation Treaty) was introduced in 1970 between member states with the purpose of having a unified filing system. A more debated agreement is the TRIP (Agreement on Trade-Related Aspects of Intellectual Property Rights). This agreement was introduced in 1995 within WTO members and ensures that member states provide strong intellectual property rights. The market for patents is now global and it includes different types of patent "aggregators" (Wang, 2008), sharing the same purpose of creating monopoly by obstructing others to use patented innovations. It is argued by Boldrin and Levine (2005), among others, that patents are necessary in some industries and not in others. The authors use the pharmaceutical industry with its high R&D costs as an exception that needs patents to encourage financing. In Chap. 9 we discuss briefly the idea of digital cooperative platforms that are one way to make radical innovation more cooperative. Yet, VC funds did operate and they are still operating in the current environment of strong IP laws.

5.4.2 The Role of Patents in VC Funds

Patents are a way to insure economic rent for the successful development of radical ideas in technology. As such they affect the value of early stage new companies that are based on radical ideas. Shares in such companies are assets of VC funds. The effect of patents on the assets and therefore on the value of VC funds is illustrated by the following example.

Assume that a group of entrepreneurs approach a venture capital fund with an innovative technology idea. Assume further that by the time of the approach the entrepreneurs already register a patent on their idea. The VC fund decides to invest 100 in a new early stage company based on the idea of the entrepreneurs. The venture capital fund and the entrepreneurs set up a new company (start-up). The new company has two assets: cash ($100) and an idea. VC funds never pay the expected value. In reality, what they pay has no relation to the ex-ante valuation based on the business plan of the entrepreneurs. According to the assumed contract between the entrepreneurs and the VC fund, the fund receives 40% of the shares of the new start-up and the entrepreneurs receive 60% of the shares. The entrepreneurs agree to spend the cash received from the VC fund on the labor necessary to develop and test the idea.

The value of the idea is derived from the payments by the VC fund. Given a payment of $100 for 40% of the share of the value of the idea (the only asset of the company) is $250. The cash contribution of $100 is an asset, but there is an obligation to use it for wages. Therefore, in an economic balance sheet there is an asset of $100 (cash) and liabilities to labor of $100 (in an accounting based balance sheet there are no liabilities to labor). Therefore total assets and liabilities are $350 as above. The VC agrees to pay $100 after the patent is registered. The balance sheet of the start-up on the first day is described in Table 5.1.

Assume further that the VC fund has only one investment and that its total capital prior to the investment was $100. The economic balance sheet of the VC fund looks as follows (Table 5.2).

The assets of the start-up are the risk-adjusted net present value of its future cash flows and the liabilities are the risk-adjusted current value of the future payments of the start-up. For simplicity, assume a two-period model where the start-up invests $100 (labor inputs) in period one and

Table 5.1 Economic balance sheet of a start-up

Assets		*Liabilities and net worth*	
Cash	100	Liabilities to labor	100
Idea	250	Equity of entrepreneurs	150
		Equity of VC fund	100
Total	350	Total	350

Table 5.2 Post-investment balance sheet of the VC fund

Assets		*Liabilities and net worth*	
Equity of start up	100	Liabilities to LP and GPs	100
Total	100	Total	100

Table 5.3 Cash flow-probability correlation

Cash flows	*Probability*
0	0.95
10,000 (=4000 + 6000)	0.05

will receive cash flows in the second period. The cash flows generated by the investment in period 2 as a result of the investment and their probability are described in Table 5.3.

Due to the high risk, the VC fund pays \$100 where its expected value in this case is \$500. The current value of the idea is based on what the VC fund paid for its share of the equity. In case of success in our example, the cash flow from the investment will be \$10,000. The cash flows are composed of two parts; 4000 is the value of the cash flows if the entrepreneurs would not have a patent. Given a patent the cash flows in case of success will be 10,000. The patent protection increases the cash flows given success from 4000 to 10,000. The reason for the increased cash flows given success and a patent is that the patent prevents competition and gives the developers and the financiers of the new idea economic rent. In extreme examples when the radical idea is easy to copy once it is developed, not having a patent makes an investment impossible. Without a patent the VC would ask for more than 40% of the shares. In the example above where the VC is asked to invest \$100 for an expected value of \$200 (\$4000 × 0.05), no patent would probably lead to no deal.

The following is a description of a real case where the inability to have a patent prevented what might have been a profitable and useful new medical test. In the mid 1990s, a scientist came up with a test for HIV based on a biological analysis which was radically different than the then-common test based on chemical analysis. The main advantage of the new test was the very short time needed to get an answer. The then common test took two weeks to develop an answer whereas the new biological test required only 24 hours to develop an answer. The response of VC funds to this idea was extremely positive and a negotiation with the entrepreneur for an investment in a new start-up to develop and commercialize the proposed test was begun days after the preliminary approach by the entrepreneur. During the negotiation it was found that the entrepreneur (a professor of biology) had presented a paper in a scientific conference describing the idea of such a biological test for HIV and therefore the entrepreneur cannot get patent protection for the idea. The interest of the VC funds in the idea went down to zero.

The lack of interest can be understood by examining the data presented in the example above. Let us examine the return on the investment in the start-up described above. There is a 5 % probability of success. Once success is achieved the rate of return on the investment of $100 in developing the idea is extremely high. In cash-on-cash terms the investment achieved a multiplier of 100× (the value is 10,000 if successful with a patent). Realizing such a high rate of return (multiplier) can be only the result of a monopolistic position of the start-up company given the success. A monopolistic position that yields such high profits can be maintained only if it is legally protected by a patent. Going back to the HIV test example, suppose that the development and the commercialization of the new test turns out to be successful and the new start-up set up for the development and commercialization of the new test. Assume further that potential consumers are willing to pay $100 per unit where the cost of production is $10. The new company will be very profitable (hence the high return). However, if the new idea is not protected, competitors will enter the market and the price will get down to $10 where the producer's surplus is zero. As was discussed in earlier chapters, GPs of VC funds do not invest in projects that do not yield a substantial producers' surplus if they are successful.

Geronikolaou and Papachristou (2008) have discussed and tested the relationship between patents and VC investment. Based on the literature in the field, they have presented two hypotheses about patents and VC funds. The first hypothesis is that an arrival of new technology (resulting in increased number of patents) increases demand for VC capital by driving new firm start-ups. This hypothesis was specified by Hirukawa & Ueda, (2011). The second hypothesis is based on the irreversibility-delay proposition of Dixit and Pindyck (1994), which claims that the decision to invest may be deterred in the presence of uncertainty over future cash flows. Geronikolaou and Papachristou test the hypothesis that because of information asymmetries and irreversibility considerations, patents generate VC activity. Their test, based on European data in 15 countries obtained from the EVCA, supports their hypothesis. In accordance with these results Mina & Lahr (2013) show that VC investors use patents as a signal of know-how and commercial viability, saying that the patent has a selection function. Our analysis supports the positive relationship between patents and VC investment, but the reason is not a reduction in uncertainty in the selection process, but rather an increase in value, given success.

5.5 Government Support of Institutional Savings

Eighty-five percent of the capital committed to VC funds in the U.S. is coming from institutional investors that invest and manage money for savers, who are primarily middle-class and lower-middle-class workers. The other 15 % is invested by family offices and wealthy individuals. Out of the institutional investors, U.S. pension funds provide about 40% of the capital for VC funds. Public U.S. pension funds provide more than half of this amount. The EVCA (2014) has reported that 25% of all the money that went into European private equity funds and venture capital funds came from pension funds (see Table 2.8). A 2012 report published by the U.S. Government Accountability Office (GAO) indicated that in the period from 2001 to 2010 about 70% of all large Defined Benefits Plans in the U.S. invested capital in private equity and venture capital funds. This is a new phenomenon, and it is very different from the way that radical ideas in technology were financed in earlier periods. The Bell telephone company, and later AT&T, were financed by a small group of wealthy individuals. One of them, Hubbard, was a lawyer and the father-in-law of Alexander Graham Bell. The parallel processes of a change in the source of radical ideas from individuals to research institutions and the growth of middle-class savings as a source for investment has shifted the financing of radical ideas from individuals to institutions. This would not have happened without the active intervention of the U.S. government.

The major role of the institutional savings of middle-class and lower-middle-class workers in the U.S. as the main suppliers of capital for investment is a relatively new phenomenon. The following brief timeline of the evolution of institutional savings in the U.S. and major government interventions shows how this process came about.

The timeline, Fig. 5.3, demonstrates two related processes: a rapid increase in institutional savings in the U.S., and a parallel increase in government involvement in making institutional savings more attractive to U.S. workers. Pension payments by employers became tax deductible in 1914. As early as 1940 15% of the workers in the private sector and all the workers in the public sector in the U.S. were covered by pension plans. The government intervened in the management of pension funds through the 1947 Labor Management Relations Act and, in a more thorough way, in the Employee Retirement Security Act (ERISA) of 1974. By the end of the twentieth century most of the workers in the U.S. were covered by either a contributing or by a defined benefits pension plan. This development made

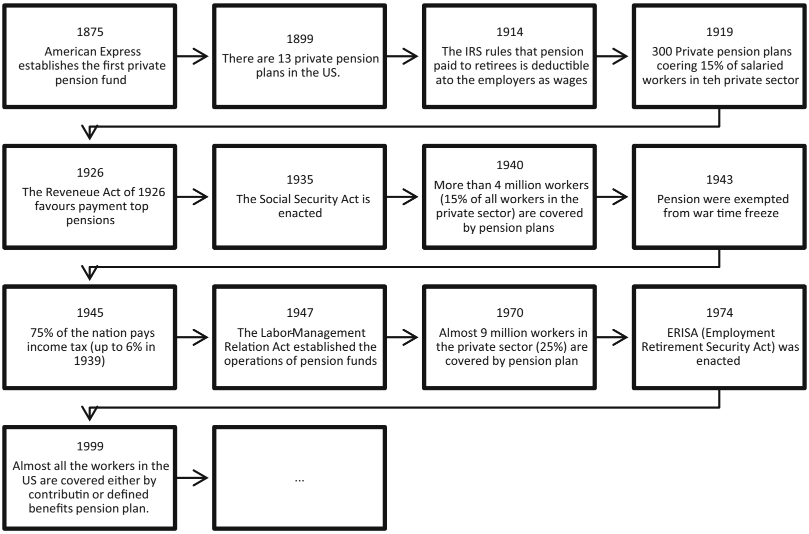

Fig. 5.3 A timeline over the development of institutional savings and government intervention. *Source*: Workplace Flexibility, Georgetown University Law Center (2010)

the lower-middle-class and the middle-class in the U.S. the groups that provide most of the capital for investment in the economy. It also makes institutional investors in general and pension funds in particular into major investors in all asset classes.

An important component in U.S.-government policy towards institutional savings is a both explicit and implicit insurance against the risk involved in the investment of the accumulated assets and the on-going contribution of the beneficiaries of pension funds. Pension plans in the U.S. are divided into two groups: defined benefits (DB) and defined contribution (DC) plans. In defined benefits plans the beneficiary, the retiree, receives a contractual pension usually as a proportion of the past wages. The beneficiary does not contribute to the plan and it is the responsibility of the employer to fund the plan. In defined contribution plans the beneficiary and the employer contribute monthly to the plan and the beneficiary receives pension based on the accumulated amount in the plan. Historically all public employees in the U.S. had DB plans as well as many employees in the private sector. In recent years there is a shift in the U.S.

from DB to DC plans. As it is shown in Agmon, Gangopadhyay, and Sjögren (2014) DB plans are a main source for capital for VC funds. Most of the asset allocation of public pension funds in the U.S. is coming from DB plans.

The position of the U.S. government towards the commitments of the employers that fund DB plans is expressed in ERISA and by the establishment of the Public Benefits Guarantee Corporation (PBGC), an insurance facility specifically for DB plans. In addition, due to political considerations, the federal government provides an implicit underwriting of all public-sector DB plans. This policy creates an incentive for the pension funds that manage DB pans to follow a high-risk investment policy that includes investment in VC funds. The interest of the employers is to minimize their contribution to the plan. The interest of the managers of the DB plans within the pension fund is to generate high return. The payments to the beneficiaries of the DB plans are not dependent on the return on the investment by the DB plans and they know that to a large extent they are insured by the federal government. The implicit and the explicit contracts between the U.S. government and the DB plans reflect political and policy consideration of the U.S. government, but as a result of these considerations DB plans have become a major source of capital for VC funds.

5.6 Summary: VC Funds, a Response to Incentives Provided by Government Intervention in the Market for Radical Ideas in Technology

Government intervention in the market for radical ideas is an old policy. In 1474, the "*Venitian Statute on Industrial Brevets*" was declared to protect the citizens of Venice from persons with the purpose of copying and infringing on innovations. One effect of the Statute was to attract innovators from other parts of Europe to settle in Venice (David, 1993). In the U.S. the policy has survived for more than 250 years. For most of this period, government intervention in the market for ideas was expressed through IP laws and their legal interpretation. Since the beginning of the twentieth century, governments in general and the U.S. government in particular intervenes in the process of generating radical ideas in two additional ways: first, by funding basic research, and second, by creating a new, large, and less personal source for financing radical ideas through VC funds. VC funds respond to all three types of government intervention. Assets of VC funds are impacted by the granting of temporary and contestable monopolies to successful developers and their financiers. The liabilities of VC funds are coming primarily from the savings of households through institutional investors. The flow of radical ideas in technology out of which GPs of VC funds select their investments is affected by basic research that is funded in part by the government.

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CHAPTER 6

How the Contracts Between the LPs, GPs, and the Entrepreneurs Facilitate Investments in High-Risk Radical Ideas

Abstract As is recognized by the U.S. Constitution, government intervention is a necessary condition for promoting radical ideas. This is due to the non-rivalrous and increasing return to scale (public-good features) of radical ideas. Governments intervene in the process of turning radical ideas in innovative technology into consumption by funding basic research, through intellectual property (IP) laws, and by encouraging and supporting long-term institutional savings. The first form of intervention increases the supply of radical ideas in innovative technology. The second affects the value of assets based on radical ideas if successful, and the third makes it easier to finance VC funds by institutional investors. Government intervention creates economic rents. It is shown in the chapter that in the market for ideas, temporary and contestable monopolies are welfare increasing.

Keywords Contract • VC • Limited partners • general partners • radical ideas

6.1 Introduction

Like any financial intermediary, VC funds transfer funds from savers to investment projects. The basic contract that sets up VC funds defines that they will invest in radical innovative ideas in technology. The nature of the investment project determines the two operational contracts that

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rule their operations: the contract between the limited partners (LPs) and the general partners (GPs), and the contract between the VC funds and the entrepreneurs. The contracts between the LPs and the GPs affect the liabilities of VC funds. The contracts between the VC funds and the entrepreneurs affect the assets of the VC funds. VC funds invest in radical innovative ideas in technology. This is a unique class of assets different than most assets in the portfolio of institutional investors and through them in the portfolio of the households. The uniqueness of radical ideas as a basis for potential assets is reflected in the unique nature of the contracts that form the liabilities and the assets of VC funds.

6.2 VC Funds and the Role of Financial Intermediation

Households, savers, and investors will maximize their utility by giving up some consumption today and use that for investing in projects to secure future consumption. Households, being risk-averse, have a preference for low-risk investment. For the same reason, households will prefer smaller projects, or parts of projects, which allow for diversification and better match the generally lower amount which they commit for investment (Fig. 6.1). On the opposite side of the picture is the producing sector, whose projects often have a long duration (and hence low liquidity). These projects

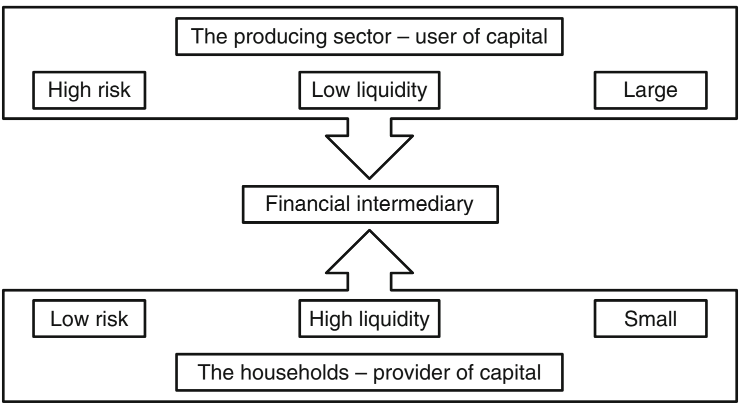

Fig. 6.1 The role of financial intermediary—matching households' preferences with the supply of real world projects

are large and high-risk. The matching of the supply of investment to the demand of savings for future consumption needs financial intermediaries. The financial market, with their actors, such as banks, brokers, hedge funds, pension funds, and so on, are all special-purpose entities lowering the transaction cost of transferring money from the demand-side to the supply-side. Banks, for example, transfer savings to debt instruments and mutual funds transfer savings to equity. In this chapter, the financial intermediary is the VC fund (we will also describe the pension fund as a financial intermediary between household savings and production in the next chapter). Because ideas are inherently non-rivalrous, risky, and inseparable from human capital, traditional markets for ideas are uncommon (Gans & Stern, 2010). Instead, trades of ideas are settled in a negotiation between two parties.

A wide body of literature tries to explain the specific role of VC funds as intermediaries between high-risk capital and potentially successful radical ideas. Explanations provided in the VC literature claim that VC-backed companies are more professional in human resources policies, compared to non VC-backed companies (Bottazzi, Da Rin, & Hellmann, 2008). The literature also claims that GPs bring business experience, hands-on help with recruiting, and independent professional boards to firms they support (Baker & Gompers, 2003). VC-backed firms are also found to be more active in patent applications; moreover, their patents are more valuable compared to non VC-backed firms (Kortum & Lerner, 2000) and have shorter time to market Hellman & Puri, 2000, 2002). One problem, called 'survivorship bias', is that we can only observe the successful investment projects of VC funds, as only VC backed companies that went through exit and survived long enough to have accumulated data are included in the sample.

A related question is, why do existing, non-VC-backed firms (incumbents) not use the same inputs as VC-backed firms? These inputs are available in the market. Lerner (2009), investigating recent studies, writes that incumbents may have "blind spots", such as weak incentive structures, or organizational constraints rooted in traditional low risk strategies, which make them less innovative. This does not appear to be a valid explanation. It is unlikely that the reason why financing of new ideas is funneled via VC-funds is due to the weaknesses of incumbents, particularly as VC-backed companies like Microsoft, Apple, or Intel are now themselves incumbents. We suggest that VC funds are a response to market frictions and as such, are good examples of functional and structural finance[1] intermediaries aimed at transferring savings to specific, high-risk "assets in process". The specific nature of VC funds is expressed by contracts, described in detail later in this chapter. The contracts assure that VC funds will select projects with an appropriate risk profile, and speed up the time to commercialization. The VC as a new entrant in the market does not have to take into consideration the destructive part of a new commercialized product (discussed in Sect. 4.3). The limited time horizon of the contracts ensures that VC funds avoid taking protective strategic decisions.

Coval and Thakor (2005) discuss the major role of financial intermediation as building a bridge between optimistic entrepreneurs and pessimistic investors. Entrepreneurs that generate radical innovative ideas in technology are optimistic. Households (savers) are conservative. To bridge the financial gap between the optimistic entrepreneur and the pessimistic investor we need a rational financial intermediary. Coval and Thakor (2005) state that: *"The intermediary's contribution lies not in any special information processing or monitoring skills, but in its ability to credibly commit to screen projects efficiently -- something neither the optimists nor the pessimists can do, and design contracts that enable capital to be raised from the pessimists" (p.3)*. To overcome the pessimists' skepticism a rational actor forms a financial intermediary, invest some capital, and offer the pessimist investor a *"credible (riskless) debt contracts whose payoffs are divorced from the pessimists' beliefs about project payoffs. The intermediary itself accepts junior (risky) debt claims on projects – which could also be interpreted as preferred stock – that compensate for its screening cost and make it incentive compatible for it to screen projects. All optimistic entrepreneurs get funded."* (Ibid, p.3).

Financial intermediaries like public pension funds construct a large and diversified portfolio by collecting savings from a very large number of households through long-term contracts between them and their beneficiaries. This makes it possible to invest savings in risky and sometimes illiquid investment projects and yet maintain low risk level for the individual saver (compare Fig. *6.1*). In general large institutional investors mimic the market created by the other financial intermediaries especially the stock and bond markets. Therefore they allocate very small portion of the portfolio to the unique high risk radical ideas that if successful become a part of the market portfolio. VC funds act as a connector (or a bridge to use Coval and Thakor terms) between household and high risk radical ideas.

Coval and Thakor suggest that financial intermediaries create credibility in their selection process of risky projects by assuming some of the risk. GPs in VC funds participate in the investment in a very minimal way (usually about one per cent of the committed capital), but they do assume personal risk as they have very high alternative cost. The following example illustrates the nature of the alternative cost bore by GPs in VC funds. When a GP signs a contract with LPs in a new VC funds she has two constraints; time constraints and capital constraints. GPs have to select projects, negotiate the initial investment, manage the projects and if successful organize 2–3 consecutive investment rounds and then organize an exit all within 10–12 years. The total payoff for GPs depends on the return on the total committed capital over the life time of VC funds. GPs receive payments (above management fees) only if the return on the fund as a whole exceeds an agreed upon hurdle rate. The contract between VC funds and GPs specifies that GPs invest in very high risk projects. The data presented and discussed in Chap. 2 above shows that large proportion of the investment projects selected by GPs in the U.S. end up with a loss or with return below the hurdle rate. That means that GPs are aiming at project that if successful will yield very high return. Bad selection of projects by GP will lead to no return on a substantial effort over a number of years. The nature of the investment targets of VC funds and the contract between LPs and GPs create a strong incentive for GPs to put much effort in the selection and management process of their investment projects. The cost of mistakes is high for the GP, and that built up the GPs credibility.

6.3 Radical Ideas Are Examples of High-Risk Assets

The high risk of the assets in which VC funds invests arises from the nature of radical innovation. Radical innovative ideas can be either successful or unsuccessful there is no middle ground. The time constraints built into VC funds as limited partnerships means that GPs have "one shot". In Chap. 8 below we discuss the risk distribution of assets based on radical ideas in the context of valuation of VC funds. The examples of well-known successes and failures of investments by VC funds illustrate the "all or nothing" character of investments in radical ideas. AllAdvantage an internet advertising agency was established in 1999 by three entrepreneurs; Pohle, Anderson and Brock. The company was funded by $200 million investments by a number of VC funds. For example, in 2000 AllAdvantage completed $100 million investment round led by SOFTBANK Capital Partners that invested $70 million and led a group of other VC funds that together invested $30 million. Early in 2001 AllAdvantage closed its operations with a loss of $200 million to the VC funds that invested in the company. Prockets Network is another large size failure. Prockets Network was founded in 1999. The purpose of Prockets was to design innovative router. The company raised $300 million. In 2004 Cisco acquired the intellectual property of Prockets Network for $89 million. Successes of VC investments were as big. A recent example is Nest. Nest was founded by Fadel and Rogers, two ex-Apple engineers in 2010. Two VC funds, KPCB and Shasta invested $30 million in Nest in two investment rounds in 2010 and in 2011. In 2014 Google has acquired Nest for $3.2 billion. KPCB realized $400 million on an investment of $20 million. The investment was made as a part of KPCB XIV Fund of $210 million which means that profits from one highly successful investment was equal to the total capital committed to the fund. Shasta realized $200 million on an investment of $10 million out of a $250 million AllAdvantage, Procket Networks, and Nest are extreme examples, but they demonstrate the binomial big losses and big profits of investment projects selected by GPs for VC funds.

6.4 The Contracts That Forms VC Funds

6.4.1 The Contracts Between the LPs and the GP

In a well-known study Holmstrom and Milgrom (1991) discuss the problem of compensation systems that deal with allocation of risk and rewarding productive work. DeMarzo and Kaniel (2015) extend the conceptual model of Holmstrom and Milgrom to a case of contracts between one principal and many agents where the performance of the agents is measured relative to their peers. Holmstrom and Milgrom and DeMarzo and Kaniel are discussing in their studies different markets and different situations, but their models contribute to better understanding of the contract between LPs and GPs. Large institutional investors divide their allocation for high risk assets based on radical ideas to a number of VC funds they also decide how much capital is allocated to what investment projects. VC funds act as instruments for institutional investors to invest the capital that they have allocated for investment in projects based on radical innovative ideas. The institutional investors are represented by the LPs in the VC funds that provide the capital and direct the investment through the contracts between the LPs and the GPs.

The contract between LPs and GPs has two components: an explicit contract and an implicit (relational) contract. The explicit contract defines the payoff of GPs from the current VC fund that he or she manages. The implicit contract deals with the probability of raising a consecutive VC fund by the GP who manages the current fund. Both the explicit and the implicit contracts determine the amount of effort and the project-selection process by the GP. The common explicit contract between LPs and GPs is comprised of an annual management fee taken as a percentage of the committed capital to the VC plus 20 per cents of the total profits of the LPs over the life of the VC funds, given an agreed upon minimum profits (known as a hurdle rate). The effect of the explicit contract on the decision making of the GP is shown by following example. Suppose that the VC fund invested \$1000 for 40% of the shares. The management of a start-up in which a VC fund invests considers two alternative business policies to develop the innovative idea that is the basis for the startup: first,, a high risk strategy where in case of success the value is \$22,000, with a probability of .05. The second alternative is a lower risk strategy. In this case the value of the startup at the beginning of the second period in case of success is \$1500 and the probability of success is .7333. Both projects pay \$0 if they fail. The expected value of the two alternatives at the beginning of period 1 is the same: \$1100 (\$22,000 × 0.05 and \$1500 × 0.7333 respectively). The management of the start-up has to decide which strategy to follow: high-risk or low-risk (this is often a bone of contention between GPs of VC funds and the entrepreneurs in the start-up). The entrepreneurs are also employees of the start-up. As such, they have an interest in the length of their employment. As they know that there is a substantial probability of terminating the start-up soon if the high-risk strategy is followed they are likely to prefer the low-risk strategy. The contract of the GP creates an incentive for high risk taking because the share of the GP in the success depends on the size of the success and it approaches 20% of the success as the success is bigger, (this assumes no catch-up). Assume that the contract with the LPs gives the GP 20% of the return above 10%. Assume that the share for the GP is 40%. In this case the risky business policy, if successful, will pay the GP ((\$22,000 × 0.40) − \$1100) × 0.20 = \$1540. The less risky business policy, if successful, will pay ((\$1500 × 0.40) − \$1100) × 0.20 = \$100 so the GP will receive nothing. The difference in the attitude to risk is intentional, as the projects selected by GPs in VC funds comprise the most risky component of the investment by institutional investors and other investors in VC funds. The contracts will affect the GP as a decision maker to take on risk-taking behavior. The contracts between the VC fund and the entrepreneurs, discussed in the next section, create a difference in risk preferences between GPs and entrepreneurs.

The effects of the implicit contract between LPs and GPs are more long-term, but they have an impact on the investment decisions by GPs in the current VC funds that they manage. Having more than one VC fund increases the payoff to the GP greatly. Yet, according to a study by Tyabji and Sathe (2010), for two thirds of the GPs their first VC fund is also their last. Only 10 per cent of VC firms (GPs) launch more than 4 VC funds. As the lifetime of a VC fund is only 10–12 years long, a second VC fund has to be launched while the first one is still alive. This puts a large premium on early successes. If a VC fund can report 20X on an investment three years after the investment (as was the case with KPCB and Nest) it makes it easy to raise another fund. Raising another fund increases the payoff for the GP substantially. Therefore, if a first fund has a large, early success the GP's risk appetite will increase, due to the implicit relationship between a successful first fund and consecutive funds. Big successes are measured relative to market conditions at the time. This makes the payoff for the GP partially dependent on the performance of other GPs. In a situation of one principal and many agents, contracts that take into account the relative performance of each one of the agents are efficient and optimal.[2] The efficiency of the contracts between LPs and GPs, given the objective function of the LPs, explains why the payoff structure of GPs has continued in the face of much criticism.

6.4.2 The Contracts Between the GP and the Entrepreneurs

Kaplan and Strömberg (2002) conducted a thorough empirical study of contracts between VC funds in the U.S. and the entrepreneurs that provide the ideas and manage the companies in which the VC funds invest. The main findings of the study were that there is a distinction between cash-flow rights and control rights; moreover, the VC funds, indeed, the GPs of the VC funds, control the major decisions through the board. The analysis of the dynamics of the cash and control rights show that over time(i.e. in later financing rounds) the "founders'" rights decline in favor of the rights of theVC funds. If the company was doing less well than expected at the time of the investment, the power of the GP increases. The findings of Kaplan and Stromberg are congruent with the financial contracting theory as it is discussed by Hart (2001). Their findings are also congruent with the purposes of the contract between the LPs and the GPs of VC funds. Entrepreneurs in portfolio companies of VC funds have two major interests: they receive wages as executives in their start-up companies and they have a chance for capital gains from an exit if the project is successful. The first component is riskless and the second is highly risky. The wages are financed by the investment of VC funds. The entrepreneurs have an interest in using all the investment by the VC fund as more time may increase the probability of success as well as maximize their benefits from the wages. Given the time constraints discussed above, the LPs and the GPs have an interest in finding out as fast as possible if the project is successful or not. Dropping an unsuccessful project as fast as possible is in the interest of the LPs and the GPs, but not in the interest of the entrepreneurs. The structure of the contract between the VC fund and the entrepreneurs is designed to minimize the potential conflict between the VC fund and the entrepreneurs by shifting the control straight to the VC fund if the project does not perform as planned.

The contract between the LPs and the GPs makes GPs behave as if they prefer projects with very high return if successful, even at a cost of very high risk. This risk preference by GPs is translated into giving GPs decision rights that give them the power to make the strategy of the portfolio companies of VC funds congruent with their preferences for a high return conditional on success, even when it means high risk for the entrepreneurs.

6.4.3 Assets, Liabilities and Contracts

VC funds operate under capital constraints. The allocation of capital to VC funds is determined by institutional investors and other managers of savings, given the obligations to their beneficiaries and the market conditions (a low interest rate environment may increase the allocation to VC funds). Agmon and Messica (2007) provide analysis and empirical support to show that VC funds are supply-driven. GPs of VC funds begin with a fixed amount of capital and, given that, they are looking for assets that fit their objectives and the constraints set by the contract between the VC fund and the GP. This is the opposite direction than what is assumed in financial economics. In their seminal paper on the cost of capital, Modigliani and Miller (1958) present a model of the firm using an economic version of the balance sheet. Modigliani and Miller define assets as the current value of the risk-adjusted future cash flows to be generated by the firm. The liabilities (including net worth) are defined as the risk adjusted current value of all the payments paid to providers of capital. As in any balance sheet, the current value of the assets is identically equal to the current value of the liabilities (including net worth). The current value of assets and liabilities in the Modigliani Miller is an expectation, taking risk into consideration. As time passes, actual cash flows are generated and they are paid to liabilities holders according to the contracts that define the liabilities. Modigliani and Miller discuss business firms and they see the assets as creating the value, and the liabilities as a list of how the generated value is paid to those who provide capital, labor, and other inputs to the firm. VC funds are financial intermediaries and although the Modigliani Miller model is relevant for them it works in a different way. As was pointed out earlier, financial intermediation goes from the liabilities to the assets. As is discussed in Chap. 7, an institutional investor like a public pension funds allocates assets(the savings of its beneficiaries) among different asset classes. The contract between the providers of the capital, LPs, and the VC fund determines the investment by VC funds. As was discussed in Sect. 5.4.1 above, the contract between the GP and the LPs determines the actual selection of assets by the GP as well as the management of the investment. The liabilities and the assets of VC funds are expressions of the contracts between the LPs, the VC fund, and the GP. The assets are chosen based on the contract between the LPs and the VC fund and they reflect the payoff of the GP.

6.5 Summary: The Unique Nature of VC Funds as Financial Intermediaries

In Chap. 4, the distinction between incremental and radical innovation was discussed. Most of the growth of the world comes from incremental innovation, which improves current production. Companies invest in increasing future cash flows all the time. This process increases the current risk-adjusted value of the assets. The ongoing investment of the current companies requires capital. The capital is raised by issuing liabilities (including net worth). Financial intermediaries like portfolio managers of public pension funds invest in incremental innovation by investing in equity issued by existing companies. Almost all financial intermediaries transfer capital (savings) from their beneficiaries (households) to investment projects that reflect incremental innovation. The assets "lead" the liabilities. The companies decide how much they want to invest, and savings of households finance the investment. Clearly, investment decisions by firms are affected by the supply of funds. Ex post savings are identically equal to investment.

VC funds are a different type of financial intermediaries. They operate outside existing companies. What GPs of VC funds do is select a small percentage of a large flow of radical innovative ideas in technology and then invest capital in those ideas, in an effort to turn the ideas into assets that are part of the market portfolio. If successful, the radical ideas selected by GPs of VC funds become assets of new companies (through IPOs) or a part of existing companies (through mergers and acquisitions). MobilEye is an example of a VC-backed IPO and Nest is an example of a successful acquisition. AllAdvantage and Prockets are two examples of investment led by VC funds that did not end up with adding new future cash flows and assets to the market portfolio.

The different role of VC funds as financial intermediaries is expressed in the special relationship between them and the institutional investors that provide them with most of the capital. Whereas most other financial intermediation (like transferring savings to the equity and the debt markets) is done by employees of the institutional investors, VC funds are arm's length intermediaries that have a contract with the institutional investors. The three contracts that rule VC funds are the contract that specifies the horizon, the capital commitment, and the type of the investment projects, then the contract between the LPs and the GP, and finally the contract between VC funds and the entrepreneurs. These contracts are aimed to encourage VC funds to assume high risks. The construction of these contracts is functional for the inherent characteristics of ideas as being non-rivalrous (needs negotiation), binominal in the return profile (encourage risk taking), and destructive for existing assets in place (limited time horizon). In Chaps. 7 and 8 we show that this unique high-risk investment policy is optimal for the savers as well as for the institutional investors that manage the savings.

Notes

1. The phrase 'functional and structural finance' was suggested by Merton and Bodie (2005).
2. Similar results in a different context are described by DeMarzo and Kaniel (2015).

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CHAPTER 7

The Allocation of Savings to VC Funds, Consumers' Surplus and Life-Cycle Savings Model

Abstract The venture capital industry is supply determined. Capital allocation is what makes VC funds work. The focus of this chapter is on the main source of capital to VC funds (institutional investors) and on the question, why do institutional investors allocate capital to VC funds? Pension funds have fiduciary obligations to their beneficiaries. We show in the chapter that allocating a small fraction of the savings of the beneficiaries to "lottery-like" investments that, if successful, will change future consumption in a substantial way is congruent with long-term maximization of the utility of consumption of the savers. Successful, innovative, VC-backed companies increase consumption possibilities both by changing relative prices and by introducing new goods and services.

Keywords Institutional investors • life-cycle savings

7.1 Introduction

Financial contracting can be defined as the "theory of what kinds of deals are made between financiers and those who need financing" (Oliver Hart, 2001, p. 1079). Hart motivates the definition by posing the following question: "Suppose an entrepreneur has an idea but no money and an investor has money but no idea. There are gains from trade, but will they be realized? If the idea (project) will go off the ground,

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how will it be financed?" In this chapter, we discuss the way that radical innovative ideas are financed through VC funds as a way to generate "gains from trade" that will extend future consumption possibilities. Radical innovation and finance have gone hand in hand since the beginning of the modern inventive process in the Western world, at the end of the eighteenth century. The close relationship and mutual dependence between innovative ideas and finance during the second industrial revolution in the U.S. is illustrated in a study of venture capital in Cleveland in the period 1870–1920 (Lamoreaux, Levenstein, & Sokoloff, 2006). The researchers recount the beginning of a start-up company at the time named Cleveland Twisted Drill Company. Jacob Dolson Cox, a machinist from Cleveland, meets C.C. Newton an inventor of cutting tools in Buffalo, NY. Newton sets up shop to develop new cutting tools but has no money to support his inventive efforts. Cox and Newton form a partnership to move the company to Cleveland, where Cox raises the initial investment of $2000 from his father as a loan (at 7 % interest). The partnership of the two entrepreneurs that was financed by the father of one of them developed over the years to become a large and successful company called Cleveland Twisted Drill Company. The combination of entrepreneurs who have an idea and financiers who are ready to finance such ideas is still an important part of the inventive process today. Individual mechanics of the nineteenth and the early twentieth centuries were replaced by teams of scientists, and wealthy individuals were replaced by VC funds that rely on small parts of the savings of middle class savers, but providers of risk capital are still a necessary condition for successful radical innovation.

In Chap. 6 we discussed VC funds as specific financial intermediaries that finance the transition of radical ideas in technology from potential to realization. Lundvall's (2009) statement, "A substantial part of the innovative activities take place in units separated from the potential users of the innovation" is a testimony to the need for a "special unit" to perform this transition. In Chap. 5, we discuss how government intervention can contribute to innovation. Related to this chapter is how institutional savings have developed over the years. In this chapter, the focus of the discussion is on the question of why the financing of the transition of radical ideas from potential to actual contribution to current and future consumption (a contribution to consumers' surplus) is done primarily by institutional investors. To answer this question, we use the life-cycle savings model and show how pension funds, an institutional investor, contribute to secure future consumption by allocating some of their capital to high-risk VC fund investments. Another purpose of this chapter is to illustrate how VC funds, as a firm, create consumer surplus and to give some evidence of changes in consumer baskets as a result of VC activity.

7.2 The Life-Cycle Savings Model and High Risk Investments

The main motivation for savings is to provide for future consumption. The life-cycle savings model provides insights into the motivation of households to save part of their income. As most of the savings in the U.S. are done through institutional investors and institutional investors have fiduciary obligation to their beneficiaries(the saving households), asset allocation of institutional investors should reflect the preferences of their beneficiaries. Bodie, Treussard, and Willen (2007) present the three principles of savings according to the life-cycle savings model. The three principles are:

- Focus on future consumption and not on the financial plan.
- Financial assets are vehicles of moving consumption from the present to a future period.
- The value of a dollar in return for savers depends on the consumption that the dollar commands in the future.

The life-cycle savings deals with consumption and not with financial return. There is a need to motivate institutional investors to allocate capital to investments based on radical ideas that contribute to future consumption possibilities of their beneficiaries even if their aggregate return as an asset class in itself is insufficient to cover the risk as it is measured by LPs in VC funds. In the next chapter, we show that due to externalities to the portfolio of all other assets held by institutional investors, there is congruence between the financial measurement of the return on the portfolio by institutional investors and the long-term utility of consumption of their beneficiaries.

By investing in the market at large, the institutional investors who manage the savings provide the savers the protection that they seek in terms of their future consumption. This is because financial assets are the rights to future cash flows. The cash flows are generated by the production of goods and services by different organizations like corporations, financial institutions, professional service providers, and government agencies. Buying the securities issued by these organizations is the equivalent to buying rights to their future production streams. The transformation of current savings by households to actual flows of goods and services in the future through the process of financial intermediation by institutional investors is demonstrated in Fig. 7.1 below. This figure is similar to Fig. 6.1. However, the focus in Fig. 7.1 is on how households secure their future consumption, while Fig. 6.1 illustrates the need of a financial intermediary to match households' preferences with the characteristics of real assets.

Institutional investors collect savings from households and invest the money into different classes of assets like fixed income, equity, real estate, and what is called "'Alternative Investment"'. The investment is expressed by buying securities, liabilities of corporations and other business organizations by the institutional investors. The securities held by the institutional investors (bonds and equity) are claims against assets of the organizations

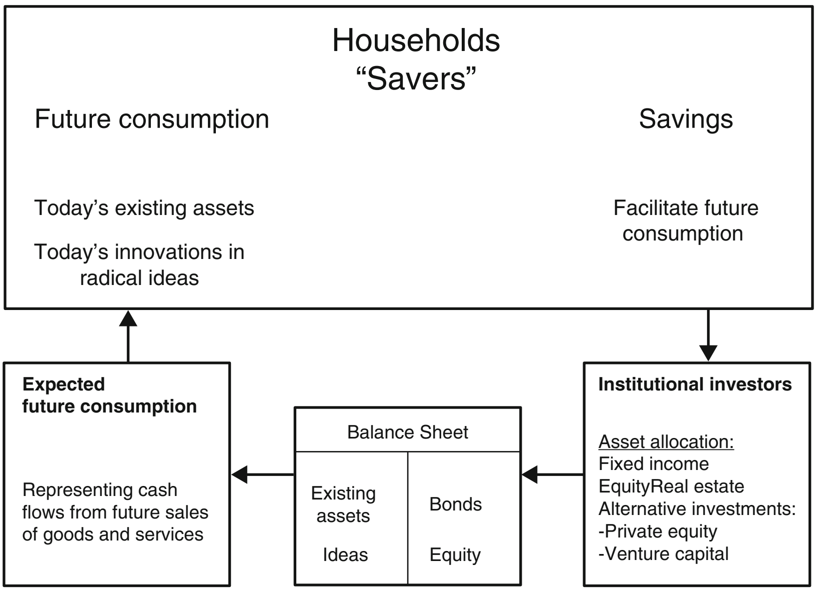

Fig. 7.1 The transformation of current savings to future consumption

that issue the securities (their liabilities). The securities held as assets by institutional investors are liabilities in a balance sheet of the companies in which they invest. The assets of these companies represent the cash flows from sales of goods and services that these companies will produce in the future. As is shown in Fig. 7.1, expected future consumption is mapped against the current assets' allocation (investment) of institutional investors. Most of the asset allocation of institutional investors goes to existing companies and other organizations that produce the goods and services that comprise current consumption and the expected improvements in future consumption due to incremental innovation. A part of future consumption is comprised of goods, services, and production technologies that do not exist today and that are not part of the process of incremental innovation. This part of future consumption depends on successful radical ideas in technology. A well-known example is the cellular phone that did not exist and was not anticipated to become an important part of the consumption basket not so many years ago. Radical ideas surprise incumbents and the market. That is why they are radical. Households do not know which radical ideas will be successful in the future. They do know that some radical ideas will be successful in the future and that their future consumption will be affected by the outcomes of these ideas. Therefore, it makes sense for households to invest some of their savings in the development testing and commercialization of radical ideas knowing well that most of them will not prove to be successful. Asset allocation by institutional investors to VC funds is a way for households to invest in the unknown changes in their future consumption as a result of radical new production processes or radical new goods and services. In earlier chapters, we have shown that successful radical ideas changed the life of most if not all consumers and that radical ideas in technology and their applications are the reason for the continuing process of increasing consumption per capita in the last 200 years. As we have shown in Sect. 7.1, appropriate financing was a necessary condition for the success of such radical ideas and their applications. The initial financing of such ideas is small.

To explain why it may be rational to invest some of the savings in radical high risk ideas we adopt a model developed by Friedman and Savage (1948). Their model explains why risk-averse households invest small amounts of money in a lottery that has a very high return if successful, but the household's expected value is negative. Their explanation is that individuals may be risk averse in making investment decisions in general, but at the same time may be willing to take on risk in lottery that, if successful, will change the life of the household in a substantial manner. Friedman and Savage explain this behavior by assuming that such changes affect the utility of the households and make the utility-adjusted expected value of the lottery (if successful) positive. In the following section, we show this by a simple asset allocation model that explains why such investment is congruent with what one would expect based on the life-cycle savings model.

This explains why we buy into a lottery, but it does not explain why we buy all the lottery tickets in the lottery. What explains the investment of institutional investors in all the VC funds in the face of what seems to be insufficient risk adjusted returns is that the reported returned documented in Chap. 8 is just a part of the total financial return to the institutional investors. In Chap. 8 it is shown that successful investment in VC-backed radical ideas has externalities to the pre-investment market portfolio. In Sect. 7.4, we show that the effects of successful investments by VC funds contribute to the long-term welfare of the beneficiaries of institutional investors who dominate current and future consumption.

7.3 Asset allocation Model for Investments in VC Funds

Conceptually, asset allocation of institutional investors that manage savings for their beneficiaries should reflect their preferences according to the life-cycle savings model. In the following, we assume that this is the case. The model is an abstraction of reality and it is based on simple assumptions. Assume an economy in which there is one person. There are two periods: present (period 1) and future (period 2). The person generates income from labor in period 1 and retires to live on savings in period 2. At the beginning of period 1, the person has to make the following related decisions:

- How much income to consume in period 1, and as a result of that decision, how much income to save and invest for consumption in period 2?
- How to allocate his or her savings among existing assets?

There are three assets in the economy and the person has to allocate the savings (investment) between the three assets: asset number one is a riskless asset with a risk-free interest rate, asset number two a risky asset with an expected return above the risk-free rate, with an assumed normal distribution of variance. Asset number three is a specific "metamorphic asset" with a binominal distribution of success with some probability of success of p and a probability of failure of $1-p$.

The three assets represent two alternative production choices: ongoing production is represented by a riskless assets (bonds) and risky assets that represent current production (an equity or a portfolio of stocks like the market portfolio). The third asset represents potential future production possibilities due to radical innovative ideas in technology. If successful, such ideas may substantially increase the value of production (and consumption). The probability of success of such investments is low. This is reflected in the high risk of the third asset.

The allocation of the savings (investment) to assets one and two is an abstraction of the debt and the equity components in the asset allocation of pension funds. Investment in asset three, the "metamorphic asset", is an abstraction of investing in a VC funds. The real world is much more complex than the simple model presented above; yet, the model helps in understanding the asset allocation of US institutional investors in general and of U.S. public pension funds in particular. U.S. public pension funds are lead investors in VC funds. Other investors often make their decision whether to invest in new VC funds by following the investment decisions of large public pension funds. The data presented below suggests that investment in the "metamorphic asset" by households is very small. The big promise of a substantial increase in future consumption is tempered by a low probability of success of each project.

CalPERS, the State of California public pension fund, is the largest single investor in the world in VC funds. By the end of 2014, CalPERS held about $2 billion in VC assets under management in its portfolio. This is about two-thirds of one per cent of the total portfolio. Pension funds provide about a third of the $200 billion of assets under management by VC funds in the U.S. Total assets managed by U.S. pension funds in 2012 were $17,000 billion. That means that about 0.4% of the total portfolio of U.S. pension funds is invested in VC funds. Public pension funds allocate more than the average to VC funds. CalPERS holds 0.7% of its portfolio in VC funds. Indiana State (INPRS) is the pension fund that invests the highest percentage of its total portfolio in VC funds, with an investment of about 1.5% of its total portfolio. With $66 billion invested out of the total of $200 billion assets under management, pension funds are critical for VC funds. Yet, with about 0.7% of the total portfolio, VC funds are not critical to pension funds. The objective of most pension funds is specified in terms of long-term return on the total portfolio. The target return reflects the "appetite for risk" of the pension fund. Due to the small allocation, the financial return on the investment in VC funds hardly affects the return on the total portfolio. It is an interesting question, then—why do pension funds in general and public pension funds in particular contribute a substantial part of the capital for VC funds where it affects neither the return nor the risk of their portfolio? In Chap. 6, it has been shown that the contract between the LPs who represent the institutional investors and the GPs who manage VC funds pushes GPs to aim at "metamorphic assets", the third asset in the asset allocation model described above, with the highest value if successful (even if the probability of success is small).

Asset allocation by institutional investors for radical ideas through VC funds differs from other asset classes. In most other asset classes institutional investors buy assets in a market like the stock market. VC funds negotiate transactions with entrepreneurs. The negotiation is dynamic, as is evident from the discussion of the GP-entrepreneur contract in Chap. 6 above. Gans and Stern (2010) discuss the nature of transacting in the market for radical ideas. Based on the literature of market design and the market for technology they conclude that due to the specific characteristic of ideas like complementarity across ideas and user reproducibility, radical ideas need personal care. In an earlier study, Gans, Hsu, and Stern (2002) show that VC funds provide such care and that they act as nurseries for ideas that may create a storm of creative destruction. The small share of investment in assets based on radical ideas makes the outsourcing of the selection and management of such investments to VC funds an efficient solution.

7.4 VC Funds Producers' and Consumers' Surplus

7.4.1 Production and Surpluses in VC Funds

VC funds are organizations that employ factors of production to generate output. They pay the factors of production that they employ and they sell the output that they produce. VC funds employ labor and capital and they produce a special type of intermediate goods that we have defined in earlier chapters as "assets in process". In this respect they operate in the same basic way as all firms do. In practice VC funds sell firms either to the market as IPOs or to other firms as acquisitions. The operations of VC funds can be discussed in the context of what is called in the strategic management literature "resource-based view of the firm (RBV)". The RBV is a particular version of a world of monopolistic competition. In such a world some providers of factors of production can and do realize an economic rent attributed to the resources that they control. Entrepreneurs are the sources of ideas. VC funds control to some extent high risk capital allocated by institutional investors and the GP of VC fund has discretion which radical idea to finance out of very large flow of radical ideas (business proposals submitted to VC funds). As was discussed in chapter five the monopoly position granted to radical ideas by IP laws. The objective of VC funds is to maximize producer's surplus, and in doing so they contribute to consumer's surplus as well. Producers' surplus is measured by economic rent (excess return) gained by the providers of factors of production like capital and labor. Consumers' surplus is the outcome of reduced prices or increased quality (or both) of a particular output.

Producer's surplus and consumer's surplus in the VC industry can be measured using a model developed by Lieberman and Balsasubramanian (2007). Lieberman and Balasubramanian developed a RBV approach to measure producer's surplus and consumer's surplus using firm level data appearing on annual financial reports. We apply this model to a VC fund to gain better understanding of the way that single VC funds contribute to consumers' surplus. VC funds hire specific labor and raise sector specific high risk capital. 'Sector specific high risk capital' is defined as capital that institutional investors allocate for investment projects with binomial distribution. The investors will receive very high return if the investment project is successful, but they are willing to lose all the capital if the investment project is unsuccessful. Armed with this capital the VC funds are looking for projects that are congruent with the incentives in the contract between the GP and the LPs. These projects are coming from entrepreneurs. Once the GP select an idea for an investment the VC fund and the entrepreneurs establish a start-up firm.

Given the two basic factors of production (labor and high risk capital) and the intermediate output the venture capital fund generate its final output which extends future consumption possibilities for consumers. The value of the production of VC funds is the market value for the startup companies in the portfolio of the VC fund. The higher is the potential value of the portfolio companies the higher is the return to the factors of production employed by VC funds. As was pointed out above the value of an exit depends on the expected value of the production of the post-exit VC backed firm which in itself depends on the added value of this company.

Table 7.1 Balance sheet of the start up after investment round one

Assets		*Liabilities and net worth*	
Cash	100	Liabilities to labor	100
Idea	250	Equity	250
Total	350	Total	350

Successful VC-backed investment projects generate very high return at the time of the exit. This excess return (economic rent) is allocated as producers' surplus between capital (LPs returns) and labor (GPs and entrepreneurs return). In the below we use a numerical example to show the development of the value of portfolio companies of venture capital funds over time. This is expressed by what is known as "investment rounds" allow measurement of the incremental value as it is valued by the market. Exit is the final stage in the life of VC backed companies. Consider the following illustration of the change in value following investment rounds (Table 7.1).

The current value of the innovative idea of the portfolio company (start-up) of the venture capital fund at investment round one is $250 (a result from a negotiation between the entrepreneur and the VC fund). This value is divided between the entrepreneurs (60%) and the VC fund (40%). The venture capital fund invested $100 in labor service in order to acquire more information about the value of the innovative idea of the start-up given success. Assume that the information acquired by the start-up was positive. As a result, there is a need for an additional investment of $300. This is called a second-round investment. After the second-round investment the current (expected) value of the future cash flows went up, from $250 to $1200. The new value of $1200 represents higher expectations. Assume that the venture capital fund has raised an additional investment of $300 from another venture capital fund at the new value of $1200. Both the value of the start-up at investment round two and its allocation among the entrepreneurs, the first venture capital fund (VC I), and the second venture capital fund (VC II) is presented in the balance sheet post-investment round two below (Table 7.2).

The new value of the startup is $1200. The new investors, VC II, invest $300 at a value of $1200 and they own 25% of equity (the cash and the liabilities to labor cancel each other). The rest of the equity (75%) is allocated at a ratio of 40/60 between VC I and the entrepreneur ($1200 × 0.75 ×0.4 = $360 and $1200 × 0.75 ×0.6 = $540 respectively). Therefore, the equity is allocated as it is presented in the balance sheet after the second

Table 7.2 Balance sheet of start up company after investment round two

Assets		*Liabilities and net worth*	
Cash	400	Liabilities to labor	400
Idea	1200	Equity of VC I	360
		Equity of entrepreneurs	540
		Equity of VC II	300
Total	1600	Total	1500

round. As more capital is needed, the balance between labor and capital is changing and therefore in second, third, and later investment rounds the share of the entrepreneurs is declining. The balance sheet above describes how the accumulated potential value of the start-up company is allocated between the VC funds that invested in the two rounds and the entrepreneurs. Given the contract between the LPs and the GPs in the VC funds that have invested in round one and round two it is possible to calculate the expected value as of the end of the second round of the payments to the GPs. The value of the VC-backed company is represented by the equity in the balance sheet. The equity is allocated between the entrepreneurs and the LPs in the first round and the LPs in the second round. The accumulation of value (equity) is the expected value to the providers of capital (LPs), and to providers of labor (GPs) in VC funds. Actual producers' surplus and actual consumers' surplus depend on exit. The RBV based analysis presented above makes it possible to measure the development of the value of the VC backed company over the investment rounds and to allocate it between producers' surplus and consumers' surplus.

7.4.2 How VC Funds Increase Consumption Possibilities

In earlier chapters we have shown that it takes time for the potential expected increase in consumers' surplus to turn into actual additional consumption. In this section, we provide some evidence on the process of turning successful radical ideas into actual consumption. The most important effect of radical ideas in technology is their reduction of the production costs of a large array of goods and services. Changes in relative prices affect consumption. A decrease in the price of a good included in the consumption basket of a consumer contributes to an increase in real consumption, through both a substitution effect and an income effect. A great part of the effect of innovative ideas in technology on both current and future consumption comes through changes in relative prices. The combined substitution and income effect is greater if the good in question is an input used in the production of many items. Microelectronics, ICT, composite materials, and biotechnology are major areas that have experienced radical changes that introduced new goods and services and new inputs that changed the relative prices of many existing products and services. Yet, the process of translating innovative radical ideas into changes in relative prices of goods and services is complex and it takes a long time. David (1990) invoking Solow's famous quip from 1987 about the computers, notes, "We see the computers everywhere but in the productivity statistics". David argues that there is an increasing return to time for new technologies but that it takes a long time to have a substantial effect. As time goes by the rate of diffusion of new technology, the increases and the relative price changes generated by new technologies are felt more and more. Doms and Lewis (2006) discuss the diffusion of PCs across U.S. businesses. In 1984, there were approximately 20 million PCs in use in the U.S. and the U.K. The number of PCs in use reached 1 billion by 2005. The contribution to productivity and the share of PC services in the consumption basket grew accordingly. A major input in PCs as well as in other IT related industries are semiconductors. The discussion of the semiconductor industry in Chap. 3 provides insights into the long process of generating idea-based changes to the relative prices of existing products and of simultaneously introducing many new goods and services.

In the following section we provide anecdotal evidence collected from various sources to demonstrate the nature and the size of the potential contribution of VC-backed firms to future consumption. One of the few attempts to measure this contribution directly is a study of the contribution of two specific digital data storage (DDS) technologies to future consumption (Austin & MacAulay, 2000). Austin and Macauley develop a model to estimate welfare gains from introduction of new technologies. The model provides a rigorous approach to forecast future benefits for consumers. In their research, they estimate the current value of the probable future benefits to U.S. consumers of the two technologies at more than $3.5 billion.

In a recent study titled "Should Low Inflation be a Concern" Papanyan and Fraser (2014) report a decline in relative prices of durable goods and decline in the proportion of clothing and footwear in the non-durable basket of goods of consumers, Tables 7.3 and 7.4.

Papanyan and Fraser conclude, "Continuous innovation and growth in the information technology sector resulted in lower prices along with

Table 7.3 Changes in relative prices of selected durable goods 2009–2013

Durable goods	*Relative price changes (%)*
Video and audio equipment	6.8
Photography equipment	6.5
Information processing equipment	5.9
Telephone and facsimile	4.4
Clocks, lamps and lighting fixtures	4.6

Source: Papanyan and Fraser (2014)

Table 7.4 Changes in the weights of clothing and footwear in the non-durable basket

Years	*Weights in basket (%)*
1964–1974	48
1984–1994	19
2004–2014	5

Source: Papanyan and Fraser (2014)

simultaneous increase in the quality of high-tech products". They continue to say that most of the benefits of this process have accrued to the consumers in the form of consumers' surplus, and only a small portion went to those who developed, commercialized, and financed the innovative process in the form of economic rent.

In the presentation and the discussion of the ideas-led growth model Jones (2005) has argued that ideas are non-rivalrous and therefore have increasing returns to scale, but the increasing returns to scale are based on an increasing number of users. As innovative production technology, when an innovative product or an innovative service becomes available they are not adopted immediately. There is a process over time where the innovative idea and its applications are adopted. In a study of the psychology of novelty-seeking behavior Schweizer (2006) says, "Innovation is not 'something new', but more appropriately referred to as 'something that is judged to be new". This observation means that the value of an innovation depends on the number of users. As the number of users grows, the value of the innovation increases. In Table 7.5 below we show data on the length of time that it has taken for major innovative technologies to reach 50% of the homes in the U.S. The data is divided into two types of innovations: General Purpose Technologies (GPT) that are used in a broad spectrum of applications as a part of the production process of many goods and services, and innovative consumers' products.

Table 7.5 Number of years that it took major GPTs and consumers' goods to reach 50% of the homes in the U.S.

Innovation	*Number of years*
General purpose technologies	
Telephone	71
Electricity	52
PCs	19
Cell phones	14
Internet	10
Consumer goods	
Radios	28
Color TVs	18
VCR	12
DVD players	7
MP3 players	3

Source: Census Bureau, Consumers Electronics Association and Theirer (2000)

The data presented above show that the adaptation time shortens relative to how recently the technology was created; for example, the Internet took only ten years to become ubiquitous. The rate of adoption of innovative ideas is often described as an s-curve. In one of the best well-known studies on the adoption of innovation, Rogers (1983) found that the potential users of any given innovation can be divided into five groups by the time that it takes them to adopt an innovative product, service, or production technology. The first group is the innovators and they are about 2.5% of the potential users. They are followed by early adopters (13.5% of potential users), then come the early majority (34%), the late majority (34%), and lastly the laggards (16% of potential users).

A case in point is the development of Nest, which we described in earlier in the book. Nest develops an application of the Internet. The application is an expression of a radical innovative idea to use Internet for communication with 'Things' rather than communication with people. However, when Nest started its operation there were few users, if any. The value was small in this initial stage. The full potential of the idea was perhaps not yet fully revealed. The success of Nest did also depend on competition from other firms aiming for market shares in communicating with 'Things'. This is evident from the small investment that KPCB and Shasta Partners made in 2010. When Google acquired Nest in 2014 the number of users had increased and this affected the value of Nest, which is in part based on the current and expected number of users. Google has acquired Nest for $3.2

billion. The potential value (increasing return to scale) of Nest's application can be deduced from a recent report published by McKinsey & Company titled, "Unlocking the potential of Internet of Things", (McKinsey Global Institute, 2015). The total value of the Internet of Things in 2025 is estimated by McKinsey & Company to be in the range of \$4–\$11 trillion U.S. dollars and the range of the value for home applications (the market in which Nest is operating) is estimated to be in the range of \$200–\$300 billion. Given these numbers, a 2014 price tag of \$3.2 billion seems to be reasonable. Most of this value, if and when it takes place, will go to consumers in the form of consumers' surplus. The extremely high return of KPCB on their initial investment in Nest, (\$400 million on an investment of \$20 million in three years) is a function of how much of the increased value for society generated by Nest as a part of Google in the next 10 years or so can be captured as producer surplus, and how much of that will fall out as consumers' surplus. In general, the allocation of the value added generated by an innovative idea in technology between producers' surplus and consumers' surplus is a function of the scale of the use (number of users). As the scale of an innovative idea in technology increases (measured by the number of users), a larger share of the added value generated by the idea goes to consumers and not to the producers. Such investments generate high economic rent for VC funds. An example is what is known as ubiquitous broadband. Crandall, Jackson, and Singer (2003) have estimated the future consumers' surplus in the U.S. of ubiquitous broadband in the range of \$230–350 billion. In a more recent study, Saunders, McClure, and Mandel (2012) indicated that telehealth is one of the most promising applications of ubiquitous broadband. In 2013, Forbes published an estimate that the telehealth market in the U.S. will grow from \$240 million to \$1.9 billion by 2018. CNBC has reported that VC investment in Health-IT early-stage companies went up from \$1.9 billion in 2013 to \$2.4 billion in 2014. This investment is an indication of the effect of a growth in the expected value of future consumers' on current investment by VC funds.

7.5 Summary

In a 2011 publication, the OECD proposed what they call more responsible and longer-term investment policies for pension funds and other institutional investors. These proposed investment policies explain the lead role of pension funds in investing in innovative ideas in technology and in management through the private equity industry. The OECD proposed investment policies are:

- More patient capital that acts in a counter-cyclical manner
- An ongoing, direct engagement as shareholder
- A more active role in the financing of long-term, productive activities that support sustainable growth such as cleaner energy, infrastructure projects, and venture capital.

The proposed policies by the OECD for institutional investors are congruent with the role of such investors in providing financing for radical innovative ideas through VC funds. GPs of VC funds play an active role in the portfolio companies of VC funds. VC funds invest in illiquid, high risk investments that may provide substantial consumers' surplus over the long-run. It takes large, well-diversified institutional investors to intermediate between the individual saver's preference for short term, low-risk and liquid investments and the societal requirements as specified in the OECD proposed policies. The progress of institutional savings in the U.S. and in other OECD countries contributes to more radical innovation, which in turns increases consumers' value. The partnership between entrepreneurs and institutional investors expressed by VC funds remains an important development in extending the inventive process and its growth implications into the twenty-first century.

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CHAPTER 8

Externalities, Consumers' Surplus, and the Long-Term Return on Investments by VC Funds

Abstract All the literature that deals with the definition of the measurement of the return on the investment in VC funds measures the return to the LPs over the relevant horizon of VC funds. Most measurements show insufficient risk-adjusted return. We show that this is an incomplete measurement. A complete measurement should take into account externalities due to spillovers that increase the return on the total portfolio held by institutional investors that allocate capital to VC funds. There is a difference between the return to the LPs in a VC fund and the returns to the institutional investors that invested the capital through the LP. The total long-term return to the institutional investors is congruent with the total return to the beneficiaries, in terms of their long-term consumption.

Keywords Return on investment externalities

8.1 Introduction

The modern valuation model is derived on the basis of a complete and perfect market. The main assumption is that investors are holding a well-diversified portfolio, called the market portfolio. The return and the risk of any given financial asset is measured relative to the risk and return relation of the market portfolio. The well-known capital asset pricing model (CAPM) is an example of the measurement of the risk and return of specific assets relative to the market. In the case of the return on

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Table 8.1 US VC funds pooled return compared to public market returns, 2014

Index	*5 years*	*15 years*	*20 years*
US VC funds	16.07	4.84	35.44
S&P 500	15.34	6.21	9.36
NASDAQ	16.97	5.85	10.85

Source: Cambridge Associates (2014)

VC funds, this is often practiced by comparing the measured return on a sample of VC funds to the return on an equity index like the S&P 500 for the same period. A recent example is provided by Cambridge Associates (2014). The data compiled and published by Cambridge Associates compares the pooled return of U.S. VC funds over various length periods to the return on S&P 500 and NASDAQ over the same periods. Table 8.1 below presents the commuted returns for durations of 5, 15, and 20 years.

In a different study of the return on investment by about 1500 VC funds over the period 1996–2005, Smith, Pedace, and Sathe (2010) reported an average return on the total investment of 13.7% with a standard deviation of 37%. The data suggests a high risk on the investment in VC funds by institutional investors and others represented by LPs in VC funds. Moreover, unlike the measurement of the return on other asset classes like equity which is done on the basis of short period, the relevant horizon of VC funds is measured in years in which there are inflows and outflows of capital. As was discussed in earlier chapters, VC funds are the financial market's response to specific planned intervention by the government, with the purpose of promoting radical ideas in technology.

8.2 The Controversy About the Return on Investment in VC Funds

In a publication titled, "Venture Capital Outperformed Major Stock Indices during Third Quarter of 2014" (January 30th 2015), Bobby Franklin, President and CEWO of NVCA, states, "*Driven by a strong exit market for VC backed companies on the cutting edge of innovation, venture capital continues to prove its worth as investible and strong performing asset class*" (p. 1). In a Harvard Business Review (2013), Diane Mulcahy, one of the authors of the Kauffman Foundation report on VC funds says, "*Although* *investors in VC funds take on high fees, illiquidity and high risk, they rarely reap the reward of high returns" (p. 1)*. The two quotes demonstrate the controversy about the return on investment in VC funds by the providers of the capital, the LPs of the VC funds. The academic literature on the valuation of VC funds based on the return to capital invested in VC funds is inconclusive. Harris, Jenkinson, and Kaplan (2014) conducted a thorough study on the return on the investment in PE funds and in VC funds. They reported that investment in the top one-half of VC funds since the 1990s yielded appropriate return relative to the relevant public market equivalent (PME). They also reported that the investment in VC funds in the 1990s yielded above PME returns whereas investment in VC funds in the 2000s yielded below PME return. As the authors of the study say, institutional investors have no ability to choose the better-performing VC funds as this is determined at the end of the life of the funds. Therefore, the appropriate measure for the evaluation of the return on the capital invested in VC funds is the average return over all funds over their horizons. Kaiser and Westarp (2010) provide an analysis of the distribution of the returns on investment of LPs in VC funds. Kaiser and Westarp show that unlike the bell-shape distribution of returns on capital assets at large, the return on the capital invested in VC funds by LPs is highly skewed. The pooled average annual return in their sample is 15.9%, but more than half of the VC funds in the sample report return between 0% and (–100%), about 10 % of the VC funds in this period have reported returns of more than 40% and about 5% of the VC funds in the sample reported annual return of more than 100%. This data is also consistent with the data reported in the Kauffman Report (Kauffman Foundation, 2012). The authors of the Kauffman Report used the data of the Kauffman Foundation, an investor in VC funds in the U.S. The Kauffman Report is based on a sample of 100 VC funds. Only 20 of the 100 VC funds in the sample reported return that exceeds the relevant PME by 3% or more. 10 of these funds were founded before 1995. (This is consistent with data reported from a bigger sample by Harris et al., 2014). 62 of the VC funds in the Kauffman Report sample reported return below the relevant PME. In the sample, 30 VC funds were large VC funds, above $400 million. Only four of these VC funds yielded return above the return on the small-cap common stock index for the same period.

Yet, even in the face of what seems to be less than expected return considering the risk and the illiquidity and what look like negative sentiment institutional investors continue to invest in VC funds. The reason for the investment in VC funds is that the measurement of the return to the capital invested in VC funds as the return to the LPs is incomplete. The missing return is the result of externalities that accrue to the institutional investors, but not directly to the LPs in the VC funds. The externalities come from the specific and different nature of the assets in which VC funds invest. The nature of the assets and how they affect the valuation of VC funds is discussed in the next section.

8.3 The Specific Risk of Assets Based on Radical Ideas

In earlier chapters, we referred to investments by VC funds as investments in "assets in process". Sudarsanam, Sorwar, and Marr (2003) present a map of what they call "knowledge assets". They distinguish between "structural resources" and "stakeholders' resources" where the former reflects the intellectual assets of the organization and the latter reflects the intellectual assets owned by individuals. Sudarsanam et al. argue that in the knowledge economy there is a process whereby the "stakeholders resources" are becoming "structural resources". A possible way to interpret this model is that ideas are becoming assets, similar to "assets in process". In almost all asset classes, institutional investors and other managers of savings (including foundations) select assets out of existing asset "inventory". VC funds invest in import new assets to the market by making new radical stakeholders' assets into structural assets. The addition of new assets to the market by IPOs of VC backed company is small relative to the stock of existing assets. However, over the years the number of assets in the market portfolio that began as VC backed IPOs is growing. An example is the NASDAQ with a total value of $6.5 trillion in 2104. The added value from IPO that year was about $22 billion.

The difference in the process of investment between assets based on radical ideas and assets already traded in the market is expressed by a different probability distribution of the future cash flows to be generated by them. Financial intermediaries that manage investment for households (savers) act as if they hold a well-diversified portfolio and they measure risk relative to the market portfolio. The market portfolio and therefore the measured risk (defined in the finance literature as systematic risk) represents the existing portfolio. The assets in which VC funds invest are different. The process of turning radical ideas into assets

Table 8.2 Statistics of the distribution of success measures given exit, 1996–2005

Measure	*Mean*	*Median*	*Skew*
Internal rate of return (IRR) (%)	13.7	9.6	5.7
Cash on cash (multiple)	1.79	1.29	8.48

Source: Smith et al. (2010)

traded in the market can be described by a binomial probability distribution. There are two stages in the process: first, the investment is either successful or not. Successful investment by VC funds ends with an exit (either an IPO or an acquisition). Unsuccessful investment ends with no exit. Data presented in Chap. 2 shows that a substantial proportion of investment projects by VC funds end with no exit. Given an exit, there is a distribution of value generated by the exit. Unlike the return on the already existing assets in the capital market, the probability distribution of value generated by exits of VC funds is not symmetric. Smith et al. (2010) estimated the distribution of outcomes given exit for a sample of 1258 VC funds for IRR and 1438 for cash on cash ratio[1] or investment multiples at the time of the exit. In Table 8.2 below, we present the statistics for the distribution of the measures of success given exit in the Smith et al. study.

The distribution reported by Smith et al. continues in later years. In 2012 the value of the top 38 VC- backed IPOs was slightly more than \$100 billion. The range of the values of this group was between \$56.9 billion (Facebook) and \$45 million (Envivio). The mean value was \$2.64 billion and the median was \$798 million: a highly skewed distribution. In the following section, we will see that the nature of the distribution of value, given success, is functional and it is the result of the contract between the GPs and the LPs of VC funds. Once the "new assets" join the market portfolio the probability distribution of the returns become congruent with the common risk-return relations in the market. In terms of asset class, successful IPOs are no longer part of VC funds' asset classes and become part of the equity market.

Ritter (2014) reports price behavior of shares issued by new companies through IPOs relative to price behavior of shares of comparable companies who have been listed on public stock exchanges in the U.S. for at least five years. In Table 8.3 below, we bring Ritter's data on a comparison between the 1st day return of the new IPOs and the three-year buy and hold return (BHR) on the new IPOs that survived for three years relative

Table 8.3 A comparison between VC backed new IPO and non-VC new backed IPOs 1980–2012

Company	*IPO (number of)*	*Average first day return*	*Buy-and-hold return 3 Years comparable*
VC backed	2773	24.8	0.6
Non-VC backed	4927	12.6	(11.6)

Source: Ritter (2014)

Table 8.4 The volatility of VC backed 1st day return and 3 years BHR by sub periods 1980–2012

	1980–1989	*1990–1998*	*1999–2000*	*2001–2012*
Number of IPOs	518	1258	517	480
First day return (%)	8.5	17.4	81.4	16.2
3 years BHR				
Comparable return (%)	14.9	25.8	(61.7)	(14.0)

Source: Ritter (2014)

to comparable already listed companies that were listed for at least 5 years. The comparison is done based on market cap and book-to-market ratio.

VC-backed returns were volatile. In periods of high exit return as measured by the average first day return, the comparable three-year BHR was low. The comparable three-year BHR of non-VC- backed new IPOs behaves in an opposite manner. This data is presented in Table 8.4 below.

The data presented in Table 8.4 show great volatility in the first-day return and the return over time (three-year holding period). High first day return was adjusted by a decline over the longer holding period return.

8.4 The Risk Preferences of GPs, LPs and the Beneficiaries of Institutional Investors

A common assumption in economics is that the welfare of the individual is the objective of the economic system. Intermediaries in institutional investors and instruments of institutional investors like VC funds are supposed to serve this goal. Yet, managers of financial institutions like pension funds and specific financial intermediaries like VC funds are individuals, and individuals may and do have different preferences. The preferences of households (savers) were discussed in Chap. 7 in the context of the life-cycle savings model. In general, it is assumed in economics and finance that individuals behave as if they are risk-averse. Yet, there are dynamic situations where allocating small portion of savings for investment in a risk-loving fashion is congruent with a long-term maximization of utility. Friedman and Savage (1948) discuss such behavior in the context of lotteries. Under contracts with payoffs that encourage risk taking, risk-averse individuals may make investment decisions resembling a risk loving behavior. VC funds in high-risk projects with a binomial probability distribution of success (e.g., either no success or a skewed probability distribution given success) is an example of the behavior described and discussed by Friedman and Savage. In this case the motivation of GPs to select projects for investment on the basis of maximizing return conditional on success is an outcome of their contract with the LPs in the framework of VC funds. This point was discussed in Chap. 6.

The preferences of the managers of institutional investors and other managers of savings reflect their fiduciary obligations to their beneficiaries and, in case of public pension funds, they have obligations to society at large as well. CalPERS, the largest pension fund in the U.S. publishes its investment objectives. We use CalPERS, an example for risk preferences and investment policies for all institutional investors. CalPERS is the largest pension fund in the U.S. and the largest single investor in VC funds in the U.S. and the global markets. The Board of CalPERS states that: *"The overall objective of CalPERS investment program is to generate returns at an appropriate level of risk to provide members and beneficiaries with benefits as required by law"* (CalPERS, 2015, p. 3). The risk and the return are measured in terms of the portfolio of all the assets. Large institutional investors like CalPERS used to say that due to their size (CalPERS' portfolio exceeds $300 billion) they mimic the market. Yet, CalPERS considers the long-term implications of current investment decisions. In an appendix titled, "Investment Beliefs" the Board of CalPERS states that the investment policy of CalPERS is long-term and that the fund "*considers the impact of its actions on future generations of members and taxpayers*" (CalPERS, 2015, Appendix 3). One can say that large institutional investors act as risk-averse investors in the context of the current market portfolio, but they are willing to invest in higher risks to increase the welfare of future generations. They do that by investing in VC funds. We will see in the next section that the long horizon and the potential additions to the market portfolio affect the return on their investments in VC funds.

The preferences of GPs of VC funds are different. As was discussed in Chap. 6, the contract between GPs and LPs is aimed at creating payoff for the GPs, a payoff that will make GPs looking for the highest potential return give success of a project almost regarding of the probability of success. GPs are looking for projects that, if successful, will yield IPO value like Facebook and not like Envivo even if the expected value of Envivo prior to the investment was higher than that of Facebook.

8.5 Direct and Indirect Considerations in Measuring the Return on Investment by Institutional Investors in VC Funds

The most important difference in measuring the return on the investment of VC funds from the point of view of the partners of VC funds and providers of capital to VC funds is the length of the horizon. Limited partners and general partners of VC funds are contractually bound by the horizon of the funds. There is a difference between the GPs and the LPs in VC funds. GPs (also referred to as Venture Capitalists) are usually organized as limited liabilities companies. Most if not all GPs want to raise a number of consecutive VC funds. Sequoia, the biggest GP firm (VC firm) in the U.S. has raised more than $6 billion over the years since its foundation in 1972 and has managed many VC funds in the U.S. and globally. Therefore GPs (VC firms) have no limited horizon. LPs in VC funds are legal structures set up as instruments to invest money and they do not have any objectives different than the objectives of the institutional investors that set them up. Institutional investors have long horizons congruent with the average duration of their obligations to their beneficiaries. The difference in the horizon makes the measurement of the return on investment in VC funds different for the providers of the capital (represented in VC funds by LPs) and the GPs of VC funds. Consider the following simple example: assume a two-period world. Investment takes place in the first period. The outcomes of the investment are received in the second period. There is one institutional investor that manages savings for all consumers and one VC fund. The VC fund raised $1000 from the institutional investor and invests it all in one start-up with a probability of success p. If successful the start-up will go public at a market value of $3000. The GP of the

VC fund will receive 20% of the profits of the VC fund. The existing companies in the economy issue equity. The institutional investor holds equity in all the companies relative to their weight in the market portfolio. After the IPO the startup become a part of the market portfolio and it is traded in fair market price relative to its expected return and its systematic risk. Assume further that the new company is based on a radical idea that contributes to economic growth. From the point of view of the economy the success of the VC-backed start-up is similar to a successful R&D operation by the economy. Nadiri (1993) summarizes the literature on the return on investment in R&D by incumbent companies and on the spillover of R&D in one industry on the profits of other unrelated industries. Nadiri reports that the spillovers are substantial and range from 20% to 110% with an average of about 50% relative to the contribution of the R&D to the industry that invests in the R&D. Assume that the new start-up after successful IPO generates spillover value equal to 10% of its value at the IPO. Given this assumption, it is possible to compute the return on the successful investment to the GP of the VC fund and to the provider of the capital the institutional investor.

- The return to the LPs:
  Given the simplifying assumption of the example above the LPs invest \$1000 and realize value of \$3000 one year later. The LP paid the GP a carryover of 20% of their profits: (\$2000) × 20% = \$400. The after carry over profits of the LP was \$1600, an annual IRR of 160%, or cash-on-cash of \$2600/\$1000 = 2.6X.
- The return to the institutional investor:
  As was discussed above, the LPs are an instrument of the institutional investor and the profit of \$1600 go to the institutional investor. However, the institutional investor holds the market portfolio. The IPO of the successful investment of the VC fund was added to the market portfolio. The new addition to the market portfolio increases its value by 10% of the increase in the value of the VC fund, \$2000 × 0.1 = 200. This value is part of the return on the investment of the institutional investor on its investment in the VC fund. The total return on the investment of the institutional investor in the VC funds is equal to the direct return accrued to the LP after fees plus the externalities (spillover effect) of the success of the investment by the VC fund. In the example this is equal to: \$2000 − (\$2000 × 0.2) + (\$2000 × 0.1) = \$1800

- The return to the GP:
  Given our simple two period model the GP can raise only one fund. Therefore its return is directly related to the profits of the VC funds without the externality. In the example described above the payment to the GP is $2000 \times 0.2 = 400$.

Measuring only the direct return to the LPs after fees as the total return to the providers of the capital is incomplete measurement. This is so as the institutional investor realizes additional return through the spillover effect over the measured return by the LPs in the VC fund. All the literature on the return on investment in VC funds focuses on the direct return to the LPs after management fees and carries over payments to GPs. There is an incongruity between insufficient risk-adjusted return over long periods of time like those reported by Harris et al. (2014), Smith et al. (2010), and the Kauffman Report (Kauffman Foundation, 2012) and further discussed in Hall and Lerner (2009) and the continuous investments in VC funds. The reported return on total investment by institutional investors in all VC funds is not high enough to pay for the risk. Institutional investors continue to allocate capital to VC funds by mimicking the market and reducing the free rider problem. Moreover, the continuous investment by institutional investors in VC funds is explained by the added indirect return due to positive externalities.

Required return is specified in terms of risk and return by measures like risk-adjusted return. Successful investment by VC funds may change the risk as well as the return in the market. The risk and the return effect relates to the transition of the asset from the "outside" to the "inside" of the market. Before the exit, there is still a high probability $(1 - p)$ that the investment of the VC funds will end with a loss of the capital invested by the institutional investor (a return of minus 100%). In this case, there is no change in the market portfolio. Given success of the investment project of the VC fund the start-up will go public and the new company will join the market portfolio. Both the return and the risk of the market portfolio will change as the result of the addition. The discussion of the semiconductor industry in Chap. 3 and the contribution of companies like Microsoft, Apple, Facebook and eBay as well as many other innovative companies discussed briefly in Chap. 2 are specific and concrete examples to the contribution of VC backed IPOs to the return of institutional investors through externalities.

8.6 Summary: The Market Is Right

The major thesis of this book is that by investing in assets based on radical ideas, VC funds fulfill an important role in the process from idea to consumption, a process that drives economic growth. Given the contribution of VC funds to economic growth, one would expect that those who manage, finance, and support VC funds will be compensated for their effort. Given the specific high risk of assets based on radical ideas as discussed in Sect. 8.3, one expects high returns for capital and for labor employed in VC funds. The literature on the return of investment in VC funds is inconclusive at best. A number of researchers and industry analysts claim that the return to capital allocated to VC funds is insufficient and that the return to GPs is too high. In Chap. 6 we show that the payment structure and the level of payments to GPs are welfare-increasing. In this chapter, we have shown that if correctly identified and measured, the return to the providers of the capital over the long horizon is substantially higher than the partial return to LPs discussed in most research. The post-exit measurement including externalities is congruent with the measurement of consumers' surplus discussed in Chap. 7. The payments to GPs, the return on the capital allocation of institutional investors over their long horizon, the real return to the beneficiaries of the institutional investors that allocate capital for VC funds, as well as the interest of the taxpayers that pay for the government support of VC funds through IP laws, funding basic research, and tab benefits to institutional savings all play a role in making VC funds a useful instrument of economic growth.

Note

1. Cash on cash is the amount the VC receives at exits divided by the amount of total investment.

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CHAPTER 9

The Future of VC Funds: The Effects of Technology and Globalization

Abstract Radical innovation and specific financial arrangements have gone hand-in-hand since the beginning of the inventive process in the West. VC funds are a specific form of financing radical innovation that depends on the nature of the technology and the organization of the capital markets. Changes in technology and globalization are changing the world now. Digital platforms are the up-and-coming form of business organizations. Globalization and the growth of China, India, Brazil and a host of small countries are changing the geopolitical and economic map of the world. People will continue to generate radical ideas, regardless of the form that the market takes. Financing will continue to be necessary. VC funds may change the way they operate, but their function will continue in one form or other.

Keywords VC funds • digital platforms • globalization

9.1 Introduction

The inventive process and its financing depends on the nature of technology and on specific institutional arrangements at different times. What remains constant is the dual process of incremental and radical innovation. In his recent book, "The Evolution of Everything: How New Ideas Emerge" Ridley (2015), questions the role government can play in funding basic

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research. His argument is that technology is *"…an autonomous, evolving entity that continuous to progress whoever is in charge"*. Technological change is a spontaneous phenomenon and should not be explained by single, heroic inventors. The electric light bulb would most likely have been discovered even without Thomas Edison. At least 23 other inventors were working on the same idea and contributed to versions of the bulb. The same can be said for many other innovations, such as the thermometer (six inventors), vaccination (four inventors), and photography (four inventors).[1] Technological change should rather be seen as a chain of parallel activities.

The story of our book is not one of the entrepreneur or the innovator. The history of the development of the semiconductor, which we discussed in Chap. 3 confirms the notion of innovation as a combined tinkering with ideas already 'in the air', leading to technological breakthroughs and technology as an unstoppable, evolving system that picks its inventors, as described by Ridley. Also, patents can be questioned as tools to spur diffusion of ideas. Even without patents, technology will find its way. Whatever process technology is, this process needs financing to develop and commercialize ideas to be enjoyed by society in large. In this book, we show that government intervention supporting institutional savings, direct funding of basic research (public goods), and IP laws (patents) increases the probability of getting ideas funded. We also show in this book that the VC as a construct is a response to market needs to fund technological change. The VC fund is a tool for encompassing the incumbents' resistance to technological change rendering old technology obsolete. This resistance is satisfied with the limited time horizon of the VC fund. The VC fund is a tool for bridging the gap between households' savings and households' desire to increase future consumption. The shaping of institutional investors, the pension funds in particular, has allowed technology to be financed without reliance on few rich individuals, and instead has pooled the savings from middle class households. This has mitigated the free-rider problem of the non-rivalrous characteristics of ideas, and contributed to a more efficient process of combining the inventive drive of individuals with the engine of basic research, fueled by the average person's desire for a better life. This combination has led to an efficient, continuous increase in the consumption per capita.

In a study of the inventive process in the early twentieth century in the U.S. Lamoreaux, Sokoloff, and Sutthiphisal (2009) discuss the dual process of innovation in the Midwest and the East Coast in the U.S. at the beginning of the twentieth century. Some innovation was done in the context of R&D in large companies, primarily in the Midwest. This activity was financed by banks and by the stock market. At the same time, smaller entrepreneurial early-stage firms on the East Coast developed innovative ideas and financed them through local sources. VC funds are an expression of the conditions at the end of the twentieth century and the beginning of the twenty-first century. They provide appropriate financial solutions for the developing and commercialization of radical ideas in technology in our time. In Chap. 5we discuss VC funds as a part of structural and functional finance. As the world changes it is likely that VC funds will developed into new forms, but the need for financing the more radical "out of the box" innovative ideas in technology will continue. In this chapter, we provide some early thoughts about the likely effects of major trends in the world of today on the future of VC funds. We focus on three major changes that may affect the future form of VC funds: changes in technology, globalization, and the increased role of government funding of VC funds, particularly in emerging markets.

9.2 Knowledge Economy and VC Funds: Digital Platforms and Crowd Financing

Digital platforms are a form of technology-based organization that is changing the way business develops via new production technologies, goods, services, and experiences. Accenture (2015) published a report of the effects of digital platforms on business. According to the report, digital platforms blur the boundaries between industries. They make the distinction between incumbents and attackers, as well as the differentiation between incremental and radical innovation, less important. The process of turning stakeholders' intellectual capital into organizational intellectual capital that is now the specific province of VC funds may become part of the normal daily activity of new, diffused digital platforms. The development of digital platforms affects patents as well. Google announced an Open Patent Non-Assertion (OPN) system related to specific patents. It is too early to assess the precise changes in IP laws as a result of the development of digital platforms, but it is clear that changes will occur. All this is likely to change the mode of operations of VC funds. Today, the focus of GPs of VC funds is on exits. Exits take place either through acquisitions or through an IPO. Either way, a precondition for the exit is forming an independent firm, a start-up which later becomes the basis for the IPO or the target for the acquisition. In new digital platforms, the innovation will be applied directly to all users and partners without the intermediation of the organizational form of a firm. Such a change, if and when it occurs may change the mode of operations of VC funds.

VC funds are financial intermediaries. As we have discussed in Chaps. 5 and 7, VC funds are a long-arm of institutional investors and other managers of savings. VC funds are a part of the flow of funds where savings of households are transferred to intermediaries that transfer the savings to particular investments. Financial intermediation is a function of the cost of collecting and processing information and other transaction costs including the intangible trust related costs. Digital platforms reduce these costs substantially. One expression of the cost reduction is the development of crowd financing. Crowd financing (also called crowdfunding) is defined by Wikipedia as a practice of funding a venture by raising monetary contribution directly from a large number of people. According to Wikipedia, more than $5 billion was raised by crowd funding in 2013. Today there are more than 1000 platforms for crowd funding, some of them are specific for early stage investments in radical innovative ideas in technology. Crowd financing is not perceived in the VC industry as a threat to VC funds; yet, it is likely that it will change the way that capital is raised by VC funds.

9.3 Globalization and VC Funds

The discussion in the book focuses on VC funds in the U.S. In recent years, the VC industry has become more global. This is shown by the number of VC funds located outside the U.S., by the number of investment projects funded outside the U.S., and by the globalization of the sources of capital for VC funds. The biggest non-US market for VC funds is China. Venture capital funding in China grew from $4 to $6 billion a year to an almost bubble level of more than $15 billion in 2014. The VC market in India is growing as well and VC investment rose to more than $1 billion in India in 2013–2014. The real globalization of the venture capital industry and of VC funds is expressed in international trade in radical ideas, in high-risk financing, and in commercialization. Two cases in point are Israel and China. Israel is a small country. From a global perspective, it has a tiny domestic market and small institutional savings. Israel also has an implicit comparative advantage in the development of radical ideas in technology. The comparative advantage is implicit as Israel needs a substantial import of high-risk sector specific capital to make the implicit comparative advantage explicit. In the case of Israel, this was done through a government intervention in the market in a program called Yozma (in Hebrew 'Enterprise'). The program was launched in 1994 with a goal of setting up 10 VC funds that will raise $30 million from foreign sources (plus $30 million each from the Israeli government and from local investors). In the 20 years that passed from the initiation of the Yozma program, more than $24 billion was raised by Israeli and US VC funds in Israel, with the result of building a strong VC sector in Israel with more than 80 VC funds and about 50,000 employees in VC-backed start-ups. However, what Israel does is produce radical ideas, develop them, and export them to the U.S. and other parts of the world. Israel is an outsourcing center for radical innovative ideas in technology. The development of R&D centers of major multinational enterprises in Israel is strengthening this process. China is a different case. The comparative advantage of China is enormous, and its growing domestic market produces a large demand for new products and production technologies. The increase in venture capital funding in China to more than $15 billion in 2014 is explained by a strong demand for mobile phones and their applications. China is also a source of capital for the venture capital industry as evident by a $6.5 billion seed-stage VC fund financed by the Chinese government. The globalization of the venture capital industry and of VC funds changes the nature of the industry. VC funds will have to adjust themselves to different business cultures and learn to operate in a multi-government world with many different regulatory environments.

9.4 Who Will Finance VC Funds, Savers or Taxpayers?

The U.S. model of VC funds is based on financing them through the savings of households. The savings are not invested directly by households. In most cases, capital for VC funds is allocated by financial institutions and intermediaries. Public pension funds are an example of the first group and family offices are an example of the second group. However, this is not the case in other parts of the world. Most of the capital for VC funds in China is coming from the government and from wealthy individuals. In Europe where VC funds have been operating for many years, government is still the single largest source of capital. According to the EVCA (2014), the share of governments in financing VC funds in Europe in 2014 was

35%. The share of pension funds in 2014 was 14%. The answer to the question of which sector in the economy finances VC funds—the government, or savers through institutional investors—has implications for the way that VC funds operate. In the U.S., the globalization of the portfolio of large institutional investors contributes to the globalization of U.S. VC funds. Matrix Partners a well-established U.S. VC fund that traced its origin to 1977. In the period 1982–2014 Matrix Partners managed 9 VC funds with capital of $2.4 billion. Two of them were in India (2006) and in China (2008). Institutional investors in the U.S. are major sources of capital for Matrix Partners. Where governments are a main source of capital for VC funds the focus is more limited. The new Chinese VC funds financed by the government are aimed at Chinese seed-level investment projects. In Sweden, the government saw VC funds and the VC industry as a way to develop Swedish SME (Karaomerlioglu & Jacobsson, 2000). In a recent Statement of Opinion on a new model for financing innovations (Statens Offentliga Utredningar, SOU 2015: 64), commissioned by the Ministry of Enterprise and Innovation, the remit and focus of the inquiry was to propose how state financial support to SMEs should be efficiently structured. One starting point was to strengthen the “financial eco system” and to stimulate Swedish start-ups and companies to grow. The Swedish state financial support should complement capital markets and support high-risk growth enterprises by using a fund structure. As the venture capital industry becomes more global, and governments of major countries like China, India, and Brazil are becoming important actors in the global VC industry, the nature of the industry and the role of VC funds as it has developed in the U.S. may change.

9.5 Summary: The Future of VC Funds

The combination of new innovative technology with the economic growth processes in many countries, particularly in Asia, in South America, and elsewhere is changing the arena for the development and financing of radical innovative ideas in technology. The combination of VC funds with capital allocated from institutional investors that was the common model for the last 25 years or so may change due to globalization and changes in technology. Changes in technology and the role of the government in the U.S. help VC funds to replace other forms of financing radical innovation in years past. The need to provide finance to innovative entrepreneurs with no money is independent of the organization structure of the capital market and from IP laws. Providing such entrepreneurs with capital is welfare increasing. Rapid changes in technology and the political and economic implications of globalization may change the way that VC funds operate and may change their legal structure, but the important role that they fulfill in the process from ideas to consumption makes it certain that in one form or another they will continue to operate for many years to come.

Note

1. Ridley's book continues the discussion of the basic issues of "demand pull" and "technology push" nature of innovation discussed by Dosi (1982), referred to in Chap. 4 above.

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Afterword

In this book we discuss how radical innovative ideas that contribute to economic growth are financed. The process of financing radical innovative ideas that turn technology into increasing consumption is complex and there are a number of actors. The following is a list of the main points discussed in the book. The list is divided into four parts:

- The objective and the process at large
- The objective of consumers/households is to maximize the utility of long term consumption including intergenerational transfers. This is expressed by an increase in the consumption per capita. The main drivers of this process are ideas.
- The main actors
- The main actors are households that save money that is transferred to investment. Institutional investors who allocate some of the savings of households to finance radical ideas, and the government, which intervenes in the market to allow for investing in non-rivalrous ideas with increasing return to scale, subsidize institutional savings and fund basic research.
- The facilitators
- VC funds are special-purpose financial intermediaries that are the response of the capital market to the specific nature of radical ideas as investments. The contracts between LPs that provide the capital and GPs who manage the funds create an incentive to GPs to make

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investment decisions aimed at maximizing return given success, where the probability of success is low and the return given success is very high. VC funds provide an outlet for entrepreneurs and innovators who do not fit with the business strategy of incumbents and thus VC funds encourage Schumpeterian "destructive creativity".
- The return on investment
- Returns in radical ideas are realized over the long term, beyond the horizon of VC funds. In measuring returns, one has to take into account the externalities to the market portfolio caused by spillover effects and by the long-term increase in consumption due to increase in consumers' surpluses. Once returns are measured in this way, there is congruence between the general macroeconomic statement that radical ideas contribute substantially to economic growth and the actual returns on investments by VC funds as a group of financial intermediaries.

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