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KNOWLEDGE-INTENSIVE PROPERTY RIGHTS AND THE EVOLUTION OF VENTURE CAPITALISM

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SCIENCE, TECHNOLOGY AND THE ECONOMY PROGRAM (STE)
WORKING PAPERS SERIES STE-WP - 39-2007



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KNOWLEDGE-INTENSIVE PROPERTY RIGHTS AND THE EVOLUTION OF VENTURE CAPITALISM¹

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Abstract: Venture capitalism is a major institutional innovation based on identifying economies of scope in transactions of technological knowledge, bundled with managerial competence, reputation, screening procedures and equity. It has paved the way to the emergence of new surrogate markets for knowledge, i.e. financial markets specialized in trading knowledge-intensive property rights. This development has important benefits in terms of risk management and hence profitability of investments in high-tech start-ups. The dynamic efficiency effects of the new institution also derive from the fact that the public at large, through its investments in knowledge-based income streams, contributes to the creation of new economically useful knowledge and capabilities.

KEY WORDS: Venture capitalism, Start-up companies, Nested transactions, Knowledge bundling, Knowledge-intensive property rights, Surrogate markets for knowledge.

JEL Classification O30; O31

¹ A version of this article will be published in the *Journal of Institutional Economics*. Cristiano Antonelli was funded by the European Union Directorate for Research, as part of the Integrated Project EURODITE (Regional Trajectories to the Knowledge Economy: A Dynamic Model) Contract nr° 006187 (CIT3), in progress at the Fondazione Rosselli. Morris Teubal was a Fellow of the International Center for Economic Research September-November 2005, and was funded by the EU's Prime Network of Excellence (Venture Fund project).

1. Introduction

This paper explores the role of venture capitalism as a major institutional innovation that has favoured the emergence of new surrogate markets for knowledge-intensive property rights. Venture capitalism thus represents an increasingly important mechanism for creating economically useful knowledge in modern capitalist societies. The growth of new specialized private and public capital markets (e.g., venture capital and NASDAQ) for the equity of technology companies, including high-tech start-ups, results from blending financial markets with markets for knowledge.

The origins of venture capital as a new, independent intermediary date back to 1945, when ARD was created in Boston (Hsu and Kenney 2005). However, venture capitalism as a consolidated institution and system of innovation emerged in the US in Silicon Valley during the mid-1970s (Kenney and Florida 2000, from p.98). Its evolution is inherently related to the invention of the integrated circuit in the early 1960s and the subsequent development of a semiconductor industry on the US West Coast (Kenney and Florida 2000).³ The literature is rich in detailed analyses of how venture capitalism works, particularly from the supply side, analyzing the complex dynamics of creating new small knowledge-intensive companies. In addition, it has explored the role of financial markets in providing funds for innovation activities, highlighting the role of venture capital.

This paper analyses venture capitalism from both angles, stressing the role of both the demand and the supply side. It shows how the new institution is articulated in two interrelated aspects: a) the foundation of start-ups and the eventual transformation of a subset into small *public* companies whose shares are traded in dedicated financial markets, and b) the significant increase in demand by specialized users and the general public for knowledge embodied in the new small knowledge-intensive public companies. The two aspects are clearly intertwined and cannot be separated, neither in the economic analysis, nor in the design of public policy intervention (Lerner, 2002; Avnimelech and Teubal 2005a, b). However, linking, coordinating and promoting knowledge/technology supply with demand has not been automatic. It has required new intermediation forms, involving new organizations like venture capital and new, dedicated private and public financial markets. These may be considered the third component of venture capitalism.^{4 5}

³ Strong co-evolutionary processes between venture capital and start-ups also characterized the emergence of a venture capital industry and market in Israel during 1993-97/8, see Avnimelech and Teubal 2006 and references therein.

⁴ The US, being the 'inventor' venture capitalism (interpreted not only as a venture capital industry and market), developed all three components of the system. Through globalization, follower countries benefited from this novel institution without having to develop all three components domestically. Thus in Israel venture capitalism emerged in the 1990s without Israel developing a local exit market. That is, development of a domestic venture capital industry sufficed in the favorable pre-emergence conditions at the time. It was possible to use NASDAQ, which became a global exit market and stimulated diffusion of venture capitalism to other countries. (There were around 130

The new supply of start-up companies, with bundled knowledge, managerial competence and equity, has created a new demand for knowledge. In turn, this increase in demand for technological knowledge embodied in new small public companies has enabled entrepreneurs, founders and initial investors to obtain a larger return on their investments prior to the full and profitable commercialization of their technology in product markets. This has favoured the entry of new venture capital firms and an increase in the number of new knowledge-intensive small firms. These feed a virtual system dynamics based on the interdependent sequence of institutional changes on the demand and the supply side.

As a direct consequence, the organization of the production of knowledge has changed, with a significant increase in both the demand and the supply of technological knowledge directly embodied in new small public companies. The share of patents delivered to small firms and of research and development expenditures funded by new small companies increased steadily through the last decades of the 20th century in the US (Gompers, 1994; Brown, Fazzari and Petersen, 2007).

Applying the basic tools of information economics as well as elements of an evolutionary and institutional perspective, this paper elaborates an institutionalist approach to understanding venture capitalism as the emergence of a system of interrelated and complementary institutional innovations (Stiglitz, 2000 and 2002).

2. The failure of the markets for knowledge: the limits of knowledge as a private good

Our understanding of the dynamics of technological change owes much to the pioneering contributions of Richard Nelson (Nelson 1959) and Kenneth Arrow (Arrow 1962) on knowledge as an economic good. They were the first to treat knowledge as a separate category of economic goods.

The analysis of knowledge as an economic good immediately revealed the causes of the marketplace's radical failure to perform its traditional functions and the ensuing severe risks of under-production of knowledge in market systems. The basic argument is as follows: A) Knowledge is the basic intermediary input for the increase of efficiency. B) Social desirability is a huge incentive for production of knowledge. Any economic system would dedicate most of its resources to generating new knowledge in order to increase the efficiency of producing all other goods. However, C) because of the major limitations of knowledge as an economic good in terms of non-appropriability, non-excludability, non-rivalry in use, non-exhaustibility and non-divisibility, the private

IPOs of Israeli technology companies towards the end of the 1990s, most on NASDAQ. See Avnimelech and Teubal, (2006)).

⁵ Needless to say, venture capitalism requires access to a well developed science, technology and higher education infrastructure. Its success also depends on the existence of large domestic or foreign companies with whom start-ups can link and interact (e.g. through strategic partnerships of various kinds or as markets for the technology developed), and which may be sources of start-up acquisition or sources of new technology (e.g. the well known role of Xerox PARC and Bell Labs). For an analysis of patterns of competition and cooperation between start-ups and incumbent companies in the relevant 'market' see Gans and Stern, 2002.

profitability of knowledge-generating activities lies well below social desirability. Moreover, D) because of high levels of uncertainty, both in generation and appropriation, economic systems are unable to channel the correct quantity of resources to the generation of new knowledge. Hence, they are unable to increase the production of goods via the increase in general efficiency of the production process. E) Dynamic inefficiency adds to static inefficiency: the markets for knowledge, as a stand-alone good, are inefficient and hence the necessary levels of division of labour and specialization cannot be achieved. A radical market failure is the direct consequence of the characteristics of knowledge, as an economic, private, and unbundled good (Teece, 1986 and 2000).

The failure of markets for knowledge is twofold: it is manifested both in the markets for knowledge as an output, and in the markets for financial resources necessary to undertake its generation (Antonelli, 2005). Let us consider these two interrelated aspects in more detail.

A) It is very difficult to sell knowledge as an output due to the well-known problems of appropriability and tradability. There is an intrinsic information asymmetry between vendors and customers (Akerlof, 1970). Customers have good reasons to doubt the real quality of the knowledge on sale before the vendor has revealed the actual content and the range of possible applications. Even a vendor's very good reputation does not exclude the possibility of a 'lemon', either due to unprecedented opportunistic conduct by the vendor or because of his own misjudgement. Moreover, as soon as the vendor reveals the content of the new knowledge, the prospective customers can take advantage of the new knowledge without actual payments. In this case, the 'inventor' faces a sharp decline in the chances of appropriating the stream of benefits deriving from economic applications of the new knowledge. Intellectual property rights help increase the appropriability and, to a limited extent, the tradability of knowledge. Arm's length transactions of knowledge, even with effective intellectual property rights are, however, difficult. Relevant absorption costs require the assistance of vendors within the context of long-term contractual relations. Transaction costs are very high because of the intrinsic difference between *ex-ante* and *ex-post* conditions. Knowledge is often exchanged within the institutional context provided by complementary property rights. A large portion of actual knowledge transactions takes place within global companies and diversified groups (Arora, Fosfuri and Gambardella, 2001; Guilhon, 2004).

B) The high risks associated with the radical uncertainty that characterize both generating and exploiting new knowledge limit the access of innovative projects to financial markets. Perspective lenders and investors are worried by the combined high levels of risk that a) the activities that they have funded will not succeed, and b) the new knowledge generated, will not be appropriated by the inventor, at least not sufficiently for repayment of credits and remunerating the invested capital. Even when knowledge generation is successful, lenders have good reasons to worry about dissipation arising from uncontrolled leakages of proprietary knowledge. Thus, worthy inventive activities and innovative projects risk losing out in the marketplace (Stiglitz and Weiss, 1981).

In contrast to the hypothesis of the neutrality of either equity or credit elaborated by the well-known Modigliani-Miller theorem, risk aversion inevitably leads to credit rationing for innovative undertakings. Without an appropriate structure of proprietary rights, banks are unable to provide the correct amount of financial resources to fund research and development activities. The analysis here provides additional arguments

supporting the so-called Schumpeterian hypothesis on the dynamic efficiency, as opposed to static efficiency, of monopolistic power. Large corporations protected by barriers to entry can be regarded as the institutional setting able to extract *quasi*-rents and use part of them to fund new innovative undertakings. The large corporation, moreover, can be regarded as an institution able to house the resources to fund the research activities and the competence necessary to monitor the research activities, to screen the results and to assess their potential commercial value (King and Levine, 1993).

Markets for knowledge as a good have been traditionally regarded as missing markets, in contrast to another frequently held implicit assumption that any transaction presupposes the existence of a market. Yet markets and market building are required for growth and even more for knowledge-based growth. The analysis of the emergence of a marketplace for knowledge should be the centrepiece in any current theory of economic development.

3. Venture capitalism as an institutional innovation

In this context, venture capitalism can be considered the result of the converging creative reaction to the failure of various agents in the knowledge market. This reaction has led to the emergence of a major institutional innovation that helps reduce the typical knowledge market failure by instituting an original and innovative structure of property rights (Schumpeter, 1947).

Venture capitalism and the dynamics which it generates involve a) highly skilled venture capitalists, new intermediaries combining the selective allocation of funds with the provision of competence and rare business skills; b) the selection of new technological knowledge together with the organizations within which it is embedded and the assessment of its industrial and commercial viability; c) the creation and growth of new knowledge-intensive firms; d) the listing of new knowledge-intensive firms with high potential on stock markets. In venture capitalism, the goal of new company founders and of venture capitalists is not as previously to assure company growth and profitability, but rather its listing on a dedicated stock market or its eventual acquisition by another company. Both favour e) the creation of knowledge-intensive property rights that enable risk-averse investors to spread risks by creating a portfolio of shares of new small knowledge-intensive property rights, and f) the emergence of a dedicated market for knowledge-intensive property rights where start-up shares are traded after initial public offerings. Venture capitalism can thus be considered as a fundamental step towards the creation of a surrogate knowledge market.

With the tools provided by the economics of information and institutions we shall explore the two sides of the literature on venture capitalism as a mechanism for knowledge governance (Antonelli, 2006; Antonelli and Teubal, 2007). We shall first analyze the supply side, that is, the organization of venture capital firms and the relations between them and the portfolio companies, i.e. the new knowledge intensive start-ups. Next we shall focus on the working of the financial markets where the new knowledge-intensive property rights (shares of the portfolio companies) are traded after initial public offering.

We elaborate the hypothesis that the emergence of structured trade based on recurrent and public transactions of knowledge-intensive property rights within dedicated financial markets results from collective institutional innovation paving the way to

creating surrogate markets for knowledge. Knowledge-intensive property rights thus characterize the evolution of venture capital into a broader set of intertwined institutional changes, leading to venture capitalism as a distinctive and qualifying component of global capitalism. Below we consider the role of the complex and dynamic interaction and complementarity between these key aspects in the implementation of venture capitalism as an institutional innovation.

4. The venture capitalist as a knowledge assembler

Within a neoclassical economics perspective involving both full information and perfect markets there is no room for bundling. This explains why, in the economics of antitrust and in competition analysis, bundling has always been regarded as an unfair practice through which firms try to expand monopolistic control to adjacent markets (Adams and Yellen, 1976; Carlton and Waldman, 2002). Yet bundling may be justified when information is asymmetrical and when there are transactions costs. Together with complementary goods, knowledge bundling emerges as an important institutional innovation in our context. It provides positive welfare effects when integrating diverse goods into a single product reduces overall transaction costs. It also creates bundled markets which compensate for missing markets or improve existing markets. The bundling of two or more goods can improve the overall efficiency of the system when one of the transactions is impossible or exceedingly expensive. In this case, a nested transaction allows an exchange otherwise impossible (Antonelli, 2006).

The working of venture capital firms as bundlers of knowledge and capital with other qualified intangible inputs has been well explored. Gompers (1995) highlights how the venture capitalist monitors and controls the performance of the new small companies. Sahlman (1990) and Gompers and Lerner (1996) stress the role of venture capitalists in providing management assistance to the new small companies. Gilson and Kraakman (1984) recall the importance of reputational capital that the venture capitalist gives to the new small company.

A substantial body of literature suggests that venture capital firms operate successfully because they are embedded in many social networks that play a critical role in reducing information asymmetries or in compensating asymmetries through their reputation. This facilitates selecting start-ups to invest in and increases venture capitalists' capacity to provide some form of added value to their portfolio companies e.g., in linking with specialized providers or services/inputs. Proximity and the consequent localized reduction of information asymmetries increase the *ex-ante* assessment of the reliability and sustainability of the entrepreneurs and the other partners (Sorenson and Stuart, 2001). On the other hand, venture capital firms can build up a professional reputation within circumscribed social networks. This is a key element in attracting new venture proposals and in building the syndication networks that may lead to the creation of the start-ups (Lee, Miller, Hancock and Rowen, 2000; Florida and Kenney, 1988; Kenney, 2000).

From this perspective, the activity of venture capital firms involves the bundling in various combinations of at least five classes of clearly distinct types of assets: a) technological knowledge, b) R&D capabilities c) managerial competence, d) business services, e) financial assets, f) reputation. We assume that bundling affects transactions on both sides in different combinations. Venture capitalism shows how intermediation

and bundling offer a superior institutional setting when information is costly and the environment is turbulent (Lerner, 1995; Teubal and Zuscovitch, 1997; Yiting, 1998).

The competitive advantage of venture capital firms is their reduction of information asymmetries, which they achieve by creating efficient bundles of assets, consequently reducing the transaction costs for knowledge. The literature pays little attention to asymmetrical information as one aspect of transaction costs. Indeed, the literature on asymmetric information seems separate from the literature on transaction costs, although these two aspects strongly overlap. It seems clear that by reducing information asymmetries, venture capitalists can save on transactions costs (Spulber, 1999).

Each of the assets that venture capital firms bundle cannot be easily transacted separately. A) Knowledge cannot be traded easily, and it is difficult to organize transactions even with the assistance of intellectual property rights. This is due to the problems associated with the unpredictability of the economic results of the application of a new bit of knowledge (this is even more so with tacit knowledge and R&D capabilities). B) The complementarity between managerial competence and new technological knowledge is extremely relevant, yet it is very difficult to match competent managers with the promising new technologies in the marketplace. C) The provision of dedicated business services, such as legal assistance, to secure effective intellectual property rights plays a key role in this context⁶. D) The screening of new knowledge requires rare dedicated competences. E) The reputation of qualified intermediaries, such as the venture capitalist is a key factor for signalling to the marketplace about the reliability and eventual profitability of a new start-up. F) The funding of innovation has always been problematic because of the well known knowledge asymmetries between the inventor and the prospective investor.

Transaction costs analysis makes it possible to integrate a large body of literature on venture capital firms as specialized assemblers of bundles of assets among which knowledge plays a prominent role. Venture capitalism can be considered a major organizational innovation that is based on the exploitation of latent economies of scope in transaction by active intermediaries. Venture capitalism consists of bundling services and products that cannot be traded separately. The bundling of such services and products clearly reduces transaction costs, leading to a new type of economies of scope. These economies of scope in transaction differ radically from the traditional economies of scope in terms of production costs. The term “economies of scope” was first used where the joint production of two goods costs less than their separate production. In contrast, economies of scope in transactions refers to the costs of using the market. There is a case for economies of scope in transaction when and if, *ceteris paribus* production costs, the joint transaction of two goods combined into one new product lowers transaction costs than when using the markets separately for each of them.

Formally this can be easily expressed as it follows:

$$(1) \text{ TRC}(x, y) < \text{TRC}(x) + \text{TRC}(y)$$

where TRC is average transaction costs for good x and y respectively.

⁶ Here, intellectual property rights clearly complement venture capitalism rather than substituting for them

It is important to stress here that such economies of scope in transaction costs exist both on the demand and on the supply side. Now prospective knowledge vendors find an active intermediary in venture capitalists who can reduce the transaction costs in the supply of knowledge to third parties. New prospective knowledge users can acquire knowledge embodied in new small knowledge-intensive firms.

In other words, knowledge tradability increases when it is bundled with financial assets, knowledge-intensive-business services and reputation, so as to become a knowledge-intensive property asset. Two categories of agents benefit from the reduction in transaction costs: a) knowledge producers can now try to sell their bundled output as a knowledge-intensive small company with clear advantages in terms of incentives to inventors; b) perspective knowledge users can purchase knowledge embodied in a knowledge-intensive small company and use it as an input into their own knowledge generation process. The purchase of external knowledge can complement internal knowledge and even substitute its internal generation.

We can now specify the economies of scope in transaction costs on the demand and on the supply side:

(2) $TRC(S(x, y), D(x, y)) < TRC(Sx) + TRC(Sy) + TRC(Dx) + TRC(Dy)$
where S and D specify the supply and demand for the goods x and y.

Venture capitalism allows identifying and capitalizing the benefits of latent economies of scope in transactions. Using the markets for technological knowledge, managerial services and finance as separate goods costs much more, both for prospective suppliers and customers, than the trade of a dedicated bundle of these goods. The creation of this bundle of products is efficient economically because there are economies of scope in the transaction of the new mix of products. The role of venture capitalism, as an active intermediary, is to identify the relevant complementarities among services, such as managerial competence, knowledge-intensive business services and properly screened technological knowledge, and to combine them with financial capital, or more specifically, with the translation of financial capital into industrial capital.

As the literature has shown, venture capitalism provides the opportunity for knowledge owners to sell their knowledge embodied in dedicated financial assets that embody other complementary services such as managerial competence, finance and preliminary screening. Here the reduction of transaction costs on the supply side has powerful effects in terms of creating a market for knowledge and, hence, division of labour and specialization on the supply side. On the other hand, venture capitalism provides large companies searching for new technological knowledge with the opportunity to take over the new companies incorporating such bits of useful knowledge with consequent de-listing. This has clear positive effects in terms of division of labour and specialization in the generation of new knowledge on the demand side. Lower transaction costs have a clear positive effect in terms of the convenience of external knowledge as an intermediary input - that can now be acquired in the market place- in the ongoing production of new knowledge within each firm.

In our approach, venture capitalism is articulated both as assisting the creation of new knowledge-intensive companies and in creating a new market for the property rights

of new small knowledge-intensive firms sliced up into shares. We argue that venture capitalism, at this stage of development, consists of two specific and yet intertwined and sequential forms of bundled transaction: A) an initial financing (and possibly creation) of start-up companies; and B) the venture capital exit transaction, i.e. sale of start-up shares to obtain capital gains. In the former transaction, venture capitalists provide financial services bundled with business services, reputation and a measure of managerial competence to start-ups. This is a 'private' rather than a public transaction. The subsequent venture capital exit transaction may be a 'public' financial market transaction (an IPO e.g. on NASDAQ) or a private one (merger or acquisition by another firm). In the former, the equity holdings of the now more developed or mature start-up company are transformed into shares that can be transferred to third parties as a sliced bundle of a supposedly higher level of technological knowledge, R&D capabilities and managerial competence. Especially when the exit transaction is an IPO, the transaction concerns the fragmented equity of knowledge-intensive firms that have already been tested on the markets for products (more than in the first venture capital investment transaction and possibly also when the exit transaction is the acquisition of the start-up). It is clear that the value creating impact of venture capitalists' intermediation is intimately linked with both forms of bundling.

The essence of venture capitalism can thus be grasped in terms of its providing a new composite vehicle that enables the general public, specialized investors, knowledge vendors and knowledge users to act in a new dedicated financial market as a surrogate market for technological knowledge, i.e. an instrument for the valorization, selection and distribution of technological knowledge.

This second and as yet indivisible aspect of venture capitalism has received attention, in a different context (Kortum and Lerner, 2000). We now show why it matters, how it has emerged and how the two aspects are strictly interrelated.

5. Equity finance and knowledge-intensive-property rights

The bundling provided by venture capitalism and the creation of new high-tech start-ups implies the necessary corollary of their eventual sale. Without a clear definition of the exit conditions, venture capital firms would quickly become conglomerates with little opportunity of converting their investments into liquid assets (Black and Gilson, 1998). The emergence of an articulated context for the exit of venture capital firms from the equity of the start-ups appears to result from a complex process of institutional change shaped by a sequence of many different steps. Here the analysis of the discriminating effects of risk on the forms of finance provides a basic guide to grasping the dynamics of the underlying forces (Rajan and Zingales, 1998, 2003).

The new analysis of the asymmetry between debt and equity in the provision of funds for research activities, elaborated by Stiglitz (1985), provides a crucial element for understanding this key aspect of the evolution of venture capitalism. Equity finance has an important advantage over debt in providing funds to innovative undertakings: it can participate in the bottom tail of the highly skewed distribution of positive returns arising from the generation of new knowledge and the introduction of new technologies (Hall, 2002). This has important consequences in terms of reducing both the risks of credit rationing and the costs of financial resources for research activities. Lenders need to charge high interest rates to compensate for the risks of failure and to filter out a large

portion of the new research activities to avoid as many ‘lemons’ as possible. In contrast, equity investors find an equilibrium rate of return at much lower levels because they can participate in the huge profits of a small fraction of the new ventures. The fraction of lemons that equity can support is much larger than that of debt; as a result, financial equity can provide much more funding for research activities (Carpenter and Petersen, 2002).

Elaborating on Stiglitz’s insight, it is clear that the larger the advantages of equity over finance in providing funds for risky activities, the larger is the possibility of spreading the risks while participating in the advantages of the limited portion of undertakings that fetch high levels of profit. Knowledge-intensive property rights traded on a public stock market allow investors to spread their risks and to participate in the full range of possible outcomes (Stiglitz, 1985; Stiglitz and Weiss, 1981).

Knowledge-intensive property rights traded on a public stock market provide the best exit opportunity for venture capital firms. We argue that venture capital could not develop to the levels already reached without a dedicated and public market for knowledge-intensive property-rights. Venture capital needs a market for equity where as many customers can purchase ‘slices’ of the new knowledge-intensive companies as possible in a context where much information is available about the characteristics of the firms and there is the largest possible number of potential customers. Exchanges on stock markets are ‘public.’ They differ sharply from private transactions, not only in the quantity and variety of agents involved both on the demand and on the supply side, but also and particularly in the density, frequency, recurrence and concentration of transactions. Moreover, the quality of information about the firms listed is standardized on a stock market and inspected by the regulatory authorities. Each transaction is public and everybody can easily access the relevant information about the structure of transactions in terms of density, quantities and price fluctuations. This has clear benefits for prospective investors and the general public.

The introduction of knowledge-intensive property rights allowed a radical change in the actual levels of the demand for knowledge, with huge consequences in terms of the actual levels of funding for the generation of new technological knowledge (Brown, Fazzari, Petersen, 2007).

In the early stages of venture capitalism, prior to the emergence of NASDAQ as a public capital market for technology companies (i.e. for knowledge-intensive property rights), profits from the new ventures and recovery of the initial investment could be monetized by the block sale of the start-up companies to single customers. Customers were other companies interested in the knowledge assets or, occasionally, new prospective entrepreneurs looking for alternative fields of activity. In many cases, leveraged buyouts, often structured by the entrepreneur and top managers, were the ultimate customers. Alternatively, substantial chunks of the start-ups’ capital could be placed in private markets based on spot transactions. In this case the customers could be financial investors, typically private equity funds, specialized in high-risk investments. In all cases the direct sale to other firms was, *de facto*, the single opportunity for the conversion of the new companies back into liquid capital.

As Hsu and Kenney (2005) show in their detailed analysis of the rise and fall of the ARD case, the development of NASDAQ gave an alternative exit strategy through a public market for technological companies. NASDAQ was founded in 1971 to popularize

the over-the-counter (OTC) or bilateral private securities market, which was relatively unknown at the time and not used by many stock players. NASDAQ thereby allowed companies, which did not satisfy the listing requirements of larger exchanges like the NYSE, to undertake an IPO. Initially there seem to have been two OTC-related functions: firstly, providing more and easily accessed information on such trades and, secondly, providing a framework for undertaking such transactions (although without guaranteeing execution nor the honouring of the trades agreed upon by the parties). For the information function, an electronic bulletin board was created as the first of its kind. This provided information but did not connect buyers and sellers. Nor did it 'coordinate' multi-agent supply and demand, though it helped reduce the spread between the Bid (demand) price and the Ask (supply) price. Over the years NASDAQ became a fully fledged stock market by adding (i) trade and volume reporting; and (ii) automatic, multi-agent trading systems⁷. It took some time for the emergence of a dedicated broadly based public market for the equity of such companies, in which both specialists and the general public participated (see below). This evolution towards a fully fledged public exit market resulted from a long process of discovery and change.

Without a public stock market, the exit of the venture capital firm from the portfolio company after its creation and growth was hindered by basic problems of information asymmetry and risk aversion. In order to spread the risks, each private investor should acquire a broad portfolio of shares of many new knowledge-intensive small companies (this requires a large operation). When this is not possible the number of players on the demand side is low, with clear consequences in terms of the price of the assets traded (Mason and Harrison, 2000).

A crucial aspect of venture capitalism is the trade of knowledge-intensive property rights (i.e. the shares of the new start-ups that are able to grow), which are brought to the market place by initial public offerings and the subsequent emergence of dedicated stock markets (Barry, 1990).

The trade of start-up shares on the financial markets is the ultimate act of a complex process of indirect sale of technological knowledge. Now investors can better face radical uncertainty about the prospective value of new knowledge and spread the risks. The purchase of small lots of shares of each company allows spreading the risks without committing huge amounts of financial resources. This results from two distinct and yet complementary aspects: a) the large number of shares into which the assets of each start-up are divided, where each embodies a property right on a fraction of a piece of knowledge, and b) the large number of such companies traded on the same stock market. Both help increase knowledge divisibility and hence tradability through implementing knowledge portfolio strategies. Investors can now take advantage of the new financial markets, where the knowledge-intensive property rights are traded as a surrogate marketplace for technological knowledge (Meggison and Weiss, 1991).

The creation of knowledge-intensive property rights provides the opportunity for transforming radical uncertainty into risk and to share the risks, increase divisibility, increase transparency and, hence, drastically reduce information asymmetries about the economic value of new technological knowledge (Mayer, Schoors and Yafeh, 2003).

⁷ <http://en.wikipedia.org/wiki/NASDAQ> and other sources.

A public market for knowledge-intensive property rights has many informational advantages over the private markets. In private markets individual investors and sellers meet only occasionally, and information is only able to flow through personal links and networks. Hence, transactions can only take place within a physical marketplace. This usually lies within a geographical area no more than 40 km or so from the venture capital firms. Professional associations and high tech meetings also provide marketplace 'islands' (Saxenian 1994; Sorenson and Stuart, 2001). In contrast, in public markets, information about transaction prices and quantities is publicly disclosed with evident benefits. This results in more agents being interested in purchasing knowledge-intensive property rights: the demand curve of each category of actors is thicker and larger (Myers and Majluf, 1984).

Knowledge-intensive property rights bring together three categories of traders on the demand side: a) the general public interested in placing their personal savings, b) financial operators, such as investment companies operating on the stock market and ready to participate in risky activities, since they can sell the shares of the new companies that are being acquired, including those of outperforming firms, and c) industrial companies that are searching for useful technological knowledge that can be acquired and integrated within their ongoing activities. For knowledge-users, financial markets provide the opportunity to check and assess the prospective value of the new knowledge embodied in the new companies (Brav and Gompers, 1997).

The merging of these three distinct and larger demand schedules has greatly increased the overall demand for knowledge-intensive property rights. The new aggregate demand for shares of new start-ups after initial public offering is much larger than the demand for non-embodied technological knowledge. Thus, financial investors and even individuals and, eventually, the public at large may contribute to the general process of valorization of technological knowledge, functioning as a complement to the venture capitalists (Gompers and Lerner, 1998).

The greater demand for knowledge bundled into the stock of start-ups after initial public offering raises prices for their stock and hence increases capital gains for venture capitalists. This immediately leads to larger incentives for many classes of agents: a) inventors are pushed to generate new knowledge more actively; b) more venture capital firms enter the new industry and spread their scope of activity in terms of both regional and industrial coverage; c) the funders of the syndication networks backing up venture capitalists are less reluctant to provide additional funds (Wright and Robbie, 1998).

The new articulation of financial markets allows research activities to be funded via the intertwined provision of funds to venture capitalists and the subsequent, downstream channelling of resources by trading the new knowledge-intensive property rights⁸. The provision of purchasing power to innovative firms via the increase in the value of their equity after initial public offerings plays a central role in the picture. After initial public offering the market value of the equity of promising companies increases systematically. Not only can entrepreneurs and venture capitalists who sell their shares be

⁸ From this viewpoint it may be argued that, with venture capitalism, financial markets can 'create financial value' that is converted into purchasing power and ultimately into money. In doing so, financial markets may be a substitute for banks in the key Schumpeterian role of creation of money for innovators (Schumpeter, 1912).

remunerated but financial resources can be given to new high tech firms that are in much a stronger position to increase their capital and attract new forward-looking investors. Thus, more than previously, the new, equity-based financial markets permit anticipation or acceleration of the return to investors through the generation of knowledge. This return can be achieved prior to the full commercial application of the new knowledge in the production of goods or services.

Israel's experience suggests that even peripheral economies can access NASDAQ as a 'global' capital market for floating promising domestic start-ups. The opportunity opened by globalization allows countries to take advantage of the benefits of the new financial markets for knowledge-intensive property rights without domestically creating all components of the system.

In conclusion, the creation of a new global surrogate market for knowledge, where knowledge-intensive property rights can be traded, is one of the key features and contributions of venture capitalism. The new financial market (NASDAQ) provides the context in which a new product, knowledge-intensive property rights, can be traded and exchanged among a variety of players (Gilson, 2003; Lerner 2002).

6. The emergence of venture capitalism as a complex institutional innovation

According to the traditional Arrowian approach, the trade of knowledge as an economic good, as well as financial funding of research activities, is impeded by huge transaction costs, both on the supply and the demand side. Radical information (knowledge) asymmetries have a powerful negative effect on agents looking for reliable and affordable customers for their knowledge and on agents seeking reliable suppliers of necessary knowledge. Tentative suppliers are worried about the risks of non-appropriability and dissipation of their proprietary knowledge. Tentative customers face serious problem in assessing the actual value of knowledge acquired in the marketplace. Spot interactions in the marketplace for knowledge are constrained by poor levels of transparency and high risks of opportunistic behaviour. The same is true in pure financial markets where investors are reluctant to fund risky research ventures.

Venture capitalism is part of a new institutional setting involving a class of economic agents specialized in selecting new technological undertakings and combining them with managerial competence and financial resources. A new dedicated marketplace specializing in knowledge-intensive property rights allows trading and exchanging shares of new companies. Its innovativeness lies in its internal architecture and in its impact on the general economic system.

Much literature has explored the emergence of venture capitalism and has provided a detailed analysis of its articulation. This paper has analysed venture capitalism as a radical and systemic institutional innovation based on three complementary institutional changes: the bundling of different assets and services into new start-ups, the creation of knowledge-intensive property rights and the eventual creation of a new surrogate market for knowledge with participation, not only of specialist agents but also of the general public.

Analysis of the complementarity between knowledge, as an economic good, and other economic goods, such as competence and financial resources, departs from the well

established analysis of knowledge as a separate and easily identifiable economic good (Van Burg and Kenney, 2000).

The emergence of the new market for knowledge-intensive property rights is a major institutional innovation. Trading the new knowledge-intensive property rights is the end step of a process articulated in the entrepreneurial selection and bundling of managerial and financial resources provided by venture capitalism, the creation of start-ups and the initial public offering of their shares. The creation of knowledge-intensive property rights has clearly played a major role in activating changes on the demand side that feed changes on the supply side. The larger demand in the new dedicated markets attracts both more IPOs and more customers. This leads to higher prices and hence larger capital gains. Larger capital gains favour additional supply. Additional start-ups are being created with diffusion into new regions and new industries of venture capitalism. The larger number of new portfolio companies, whose shares are traded, favours the decline of risk levels for financial investors, and new categories of risk-averse agents are attracted to the new typology of investment.

The interdependence between the supply and the demand side thus becomes apparent. On the supply side, the dynamics of the evolution of width and depth of the venture capital industry (and the related segment of start-up companies) interact with the dynamics on the demand side, with the growing thickness of the demand of each category of financial agent and the increasing variety of types of demand. This produces the typical cumulative process with positive feedback of system dynamics. The change in a system made of different and yet interrelated components is restless (Nelson, 1994).

Considering the *sequence*, the bundling of separate and yet complementary activities and resources not yet fully valorized in isolation into an integrated frame appears to be the first distinctive and qualifying element of venture capitalism. Latent economies of scope can be valorized. Such economies stem from the institutional combination and joint organization of distinct processes and activities. Thus, venture capitalism is an interesting case of an institutional innovation oriented towards exploiting joint organization, as distinct from traditional joint production, of different goods and activities. It is efficient in terms of reducing the overall knowledge transaction costs, financial transaction costs and the costs of matching managerial competence with dedicated and idiosyncratic knowledge.

The second distinctive element of venture capitalism is the creation of knowledge-intensive property rights, with the important positive effects of divisibility of knowledge, or rather, divisibility of the risks and opportunities associated with the use of new technological knowledge. The creation of knowledge-intensive property rights has considerably increased the tradability of knowledge bundled with new firms.

Thirdly, venture capitalism is an institutional innovation that has reshaped the organizational and architectural configurations of both knowledge supply and knowledge demand and created a surrogate knowledge marketplace. Surrogate markets for knowledge are a new financial institution where (equity-based) transactions deal with knowledge bundled with other assets and transformed into knowledge-intensive property rights that are highly divisible and tradable. There are strong increasing returns: the larger the public surrogate markets for knowledge, the higher are the chances that unsophisticated and risk-averse investors can participate in exploiting the economic rents arising from new knowledge. Such an opportunity to trade knowledge-intensive property

rights in large public surrogate markets for knowledge attracts additional flows of resources to fund the generation of knowledge.

Venture capitalism is the result of a long period of experimentation and mutual adaptation in the evolution of the organizational forms of venture capital firms, both in Silicon Valley (Kenney and Florida, 2000, pp. 105-111), and in other areas where venture capitalism has taken hold (for Israel see Avnimelech and Teubal, 2006). This evolution also includes the emerging structure of the intertwined working of financial markets in the upstream provision of funds to venture capital firms and the subsequent, downstream working of the trade in knowledge-intensive property rights.

Government policy has played a non-trivial role in the process. Emergence of the new markets and organizations in the US depended on or were facilitated by a number of processes or events: a) institutional changes, e.g., the 1979 amendments in the US to the 'prudent man' rule governing pension fund investments⁹; b) experimentation followed by selection, e.g. leading to limited partnership organization; c) exploitation of economies of scale/scope both in transactions costs (see section 3 above) and in fixed market building costs (see section 4 above); and d) triggering and sustaining cumulative processes of expansion and diffusion. The latter include, e.g. NASDAQ (see section 5 above) and, in Israel, the successful policy-led targeting of venture capital from 1993-7/8 (Avnimelech and Teubal, 2005a).

7. Conclusions

Venture capitalism is an institutional and systemic innovation that combines and articulates a number of local innovations in the organization of knowledge-based transactions. As such it provides a partial remedy for the traditional market failure in allocating the correct amount of resources for generating new knowledge. Venture capitalism has major systemic *effects* in terms of higher levels of selection and dissemination (and indirectly creation) of technological knowledge within the economic system. While trade of knowledge as a separate good may be difficult because of its well known limitations, it can be bundled with complementary goods and then traded. These mechanisms trigger increased levels of incentives for research activities, with clear positive effects on division of labour in generating new technological knowledge, specialization, and productivity of knowledge-generating activities. Venture capitalism has thus played an important role in increasing the birth of new high-tech firms together with its central function in favouring the social generation and exploitation of knowledge.

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⁹ Prior to that date the Employee Retirement Income Security Act (ERISA) prohibited pension funds from investing substantial sums in venture capital or other high-risk asset classes. The change in the rule opened the door to pension funds' tremendous capital resources (Gompers and Lerner 2004, pp. 8-9)

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