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Boundary Decisions and Financing Choices

in Human Capital Intensive Firms:

Theory and Evidence

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Abstract

This dissertation develops a theory of firm boundaries and financing choices in human capital intensive firms. I argue that when contracts are incomplete, power over intangible assets like knowledge and ideas accrues from having access to the asset and owning the rights to use this asset. Access has a symmetric effect on incentives of two agents in a relationship while ownership has an asymmetric one. Hence, choosing both access and ownership optimally maximizes incentives to make specific investments. Chapter 1 applies the theory to predict the optimal firm boundaries as a function of the ease of replicating knowledge. The boundary choices analyzed are mergers/acquisitions, joint ventures, strategic alliances and arms-length contracts. Chapter 2 predicts the optimal financing choice as a function of ease of stealing ideas and the nature of assets required for developing the idea. The financing choices examined are independent venture capital, corporate venture capital and a firm’s internal capital markets.
1 Introduction

Since Coase (1937), economists have distinguished transactions taking place inside firms from those in markets by recognizing that the former involve the exercise of power or fiat. In this framework, the property rights theory (Grossman and Hart (1986), Hart and Moore (1990), Hart (1995)) specifies that power is derived from ownership of non-human assets when contracts are incomplete. However, this view does not capture fully the essence of power in human capital intensive firms. Rajan and Zingales (1998, 2001) expand it by defining that power from an agent’s human capital stems from specialization in assets after the agent is provided access\(^1\) to these assets. But, they relegate power from ownership to the background since an agent’s human capital is unalienable. In this dissertation, it is argued that power over intangible assets, like knowledge and ideas, accrues from having access to the asset and owning the residual rights over the asset. Based on this complementary source of power, this dissertation develops an incomplete contracts based theory to analyze boundary decisions and financing choices in human capital intensive firms.

Chapter 1 of the dissertation develops a theory of firm boundaries in human capital intensive firms. The paper argues that when contracts are incomplete, power over knowledge accrues from having access to knowledge and owning the rights to use it. Access has a symmetric effect on the incentives of two firms in a relationship while ownership has an asymmetric one. Hence, incentives to invest are maximized by choosing access and ownership. The theory predicts that when knowledge of both firms becomes easier to replicate, they will provide less access to each other through less integration. In contrast, the firm whose knowledge is easier to replicate will acquire one whose knowledge is difficult to replicate to prevent inefficient investment by the latter. Consistent with the theory, I find that access through technological licenses is likelier in strategic alliances when patent portfolio of the alliance partners is narrow. The theory has implications for mergers/acquisitions, arms length contracts and hybrids.

Chapter 2 develops a theory of financing innovative ideas through independent venture capital, corporate venture capital and a firm’s internal capital markets. The financing choices are modeled using (a) access to an innovator’s idea and to a financier’s assets; and (b) ownership of the idea. Access has a symmetric effect on incentives of financier and innovator to make specific investment while ownership has an asymmetric one. Hence, incentives to invest are maximized by choosing access and ownership. The theory predicts that ideas which are easy to replicate (early stage ideas, and ideas lacking patent protection) and require generic assets

\(^1\)Rajan and Zingales (1998) define access as the ability to use, or work with, an asset. When the asset comprises some knowledge or an idea, access implies being exposed to its intricate details. Power from access is derived from a thorough understanding of these details.
for development must be financed by independent venture capital. In contrast, ideas that are difficult to replicate (later stage, patent protected or tacit ideas) and require specialized assets for development must be financed through corporate venture capital. Finally, ideas that are difficult to replicate but require generic assets for development must be financed using internal capital markets.

2 Chapter 1 – Firm Boundaries in the New Economy

Since Coase (1937), economists have distinguished transactions taking place inside firms from those in markets by recognizing that the former involve the exercise of power or fiat. In this framework, the property rights theory (Grossman and Hart (1988), Hart and Moore (1990), Hart (1995)) specifies that power is derived from ownership of non-human assets when contracts are incomplete. However, this view does not capture fully the essence of power in human capital intensive firms. Rajan and Zingales (1995, 2001) expand it by defining that power from an agent’s human capital stems from specialization to assets after the agent is provided access to these assets. But, they relegate power from ownership to the background since an agent’s human capital is unalienable. This paper argues that power over intangible assets like knowledge accrues from having access to the asset and owning the residual rights over the asset. Based on this complementary source of power, this paper develops an incomplete contracts based theory to analyze boundary decisions in human capital intensive firms.

In order to understand this complementary source of power over intangible assets, consider first the property rights theory where power is derived from ownership of non-human assets. Since, under this definition, there is no sense in which employees belong to a firm, we cannot distinguish between a firm which has access to important knowledge through its employees and one without it. To illustrate this point, contrast the acquisition of Netscape Communications by AOL with the acquisition of Level One by Intel. After AOL’s acquisition of Netscape, the software engineers at Netscape fled en masse. Since these software engineers possessed important knowledge, Netscape’s position in the internet browser market was undermined. In contrast, after Intel acquired Level One, all the important employees of Level One stayed on board. This acquisition enabled Intel to extend its dominance in chips from personal computers to high speed connectivity. Both AOL and Intel had the ownership rights to use the knowledge. However, only Intel had access to knowledge and ownership over it. The property rights theory, however, cannot differentiate

\footnote{Rajan and Zingales (1998) define access as the ability to use, or work with, an asset. When the asset comprises some knowledge or an idea, access implies being exposed to its intricate details. Power from access is derived from a thorough understanding of these details.}
between these two polar cases: an acquisition which destroys value since knowledgeable employees leave and an acquisition which creates shareholder value by retaining the knowledgeable employees.

Rajan and Zingales (1998, 2001)'s theory differentiates between the AOL and Intel acquisitions based on access to important knowledge. But, access to knowledge cannot provide power without the ownership rights to use this knowledge. To illustrate, consider the research alliance between MedImmune Inc and Ixsys Inc. As part of the alliance, MedImmune provided Ixsys access to its patented antibody technology through a license. Although Ixsys could acquire knowledge about MedImmune's antibody technology, Ixsys could not use this acquired knowledge for its sole commercial purposes without owning the patents to this technology. MedImmune's power over this asset was more than Ixsys's since it had access to the knowledge and owned the rights to use this knowledge. However, Rajan and Zingales (1998, 2001)'s theory does not capture this difference in power since their theory does not distinguish between Ixsys owning the patents and MedImmune owning it. Thus, access to knowledge and ownership of rights to use it are complementary sources of power over knowledge.

Consider two scientists Ram and Shyam. Ram specializes in discovering antibodies to cure new diseases while Shyam specializes in generating new drug delivery techniques. Ram and Shyam can benefit mutually by working together and giving access to each other's technologies. In the setup of this paper, access is reciprocal: Ram and Shyam get the same degree of access that they give to the other. Also, both Ram and Shyam could own their respective technologies or one of them could own both the technologies. After deciding access and ownership, Ram and Shyam make investments which are specific to the relationship. These investments determine the economic value generated through their relationship. If Ram (Shyam) makes investments to tailor his technology to suit Shyam's (Ram's), such investments enhance their joint surplus. If, on the other hand, Ram (Shyam) makes investments to replicate Shyam's (Ram's) technology and thus enhance his bargaining power in the relationship, such investments are economically wasteful since they duplicate what already exists in the relationship. In my framework, all these investments are observable but cannot be verified by a court.

The trade-off governing choice of access is as follows. If Ram and Shyam provide each other high access, their incentives to tailor their technologies is high since high access enhances the productivity of their investments. However, Ram (Shyam) would also invest more in replicating Shyam's (Ram's) technology since such investments are also more productive when access is high. Thus increasing access has the benefit of encouraging productive investments by both Ram and Shyam but also has the associated cost of promoting
wasteful duplication by both of them. Decreasing access, similarly, discourages both Ram and Shyam’s incentives to make productive and duplicative investments. Thus, changing access has a symmetric effect on the incentives of Ram and Shyam.

In contrast, changing ownership has an asymmetric effect on the incentives of Ram and Shyam. Consider transferring ownership of Shyam’s technology to Ram. Ram’s bargaining power in the relationship is determined by his outside option - his ability to work with the two technologies without Shyam’s involvement. Without ownership of Shyam’s technology, Ram’s investments to replicate it do not enhance his outside option at the margin. However, after Ram gets ownership of Shyam’s technology, such investments are very productive and enhance his bargaining power. This difference in incentives to replicate due to change in ownership is caused by the complementarity between access to knowledge and its ownership. Therefore, providing Ram ownership of Shyam’s technology encourages Ram to invest more in replicating Shyam’s technology. Simultaneously, Ram’s incentives to make productive investments also increase. While Ram’s incentives to make productive and duplicative investments increase, Shyam’s incentives to do so decrease since he loses ownership of his technology. Thus, providing Ram ownership of Shyam’s technology enhances Ram’s incentives to make productive and duplicative investments but simultaneously dampens Shyam’s incentives to do so.

Given these trade-offs, this paper makes the following point. Since power over knowledge accrues from access to knowledge and its ownership, choosing them together maximizes incentives to make specific investments. Varying access has a symmetric effect on incentives to make specific investment while changing ownership has an asymmetric one. Thus, regulating access is optimal when both firms’ incentives need to be simultaneously increased or decreased. In contrast, changing ownership is optimal when one firm’s incentives need to be enhanced while the other’s needs to be dampened.

To examine the main results, imagine that, in the above example, Ram owns a patent over an antibody which cures Malaria while Shyam owns a patent over its delivery mechanism. Since patents in Drugs and Biotechnology provide strong protection (Cohen, Nelson and Walsh(1996)), neither Ram nor Shyam can benefit by replicating the other’s technology. Further, since they bear the full cost of their investment but gain only half the increase in joint output, they under-invest in tailoring their technologies to each other. In this case, providing full access to each other is optimal. Thus, when knowledge of both parties is difficult to replicate, full access is optimal.

Now consider the case where Ram is working on a prospective technology for AIDS antibodies while Shyam
is working on a technology that will deliver such an antibody. Since both are prospective technologies, they are not protected by patents. Thus, both Ram and Shyam have strong incentives to make investments to replicate the other's technology. Since such investments do not enhance the joint output but are costly, there occurs over-investment which is socially inefficient. Increasing access, in this case, accentuates the problem of over-investment. Therefore, when knowledge of both parties is easy to replicate, minimal access is optimal.

Finally, consider the case where Ram owns a patent over an AIDS antibody but Shyam does not own the patent to its delivery technology. Since Ram's knowledge is patented, it is difficult to steal. Therefore, Shyam will under-invest. In contrast, Ram has strong incentives to invest in replicating Shyam's technology since it is not protected. Thus Ram over-invests since the marginal cost of his investment is greater than the marginal increase in joint output. Taking away ownership from Ram and giving to Shyam is optimal in this case. This is because it alleviates Shyam's under-investment while simultaneously mitigating Ram's over-investment. Therefore, transferring ownership from the party whose knowledge is difficult to replicate to the one whose knowledge is easy to replicate is optimal.

I test the univariate prediction that, ceteris paribus, access provided is greater when knowledge of either Ram or Shyam is difficult to replicate. I use strategic alliances in high technology industries to construct a proxy for access. An alliance in which a license is provided to any technology is inferred as indication of greater access compared to an alliance where no such license is provided. Further, additional features of licenses like exclusivity and geographical restrictions are employed as other proxies for access. The breadth of a firm's patent portfolio, measured across all industry categories using its patents and citations to these patents, is employed as a proxy for ease of replicating knowledge. A broad patent portfolio indicates a broad base of technological knowledge and hence a greater ability to replicate other's knowledge. Using these proxies, I find that a license is likelier in a strategic alliance when patent portfolios of the alliance firms is narrow. Further, an exclusive license or a license having no geographical restrictions is likelier when the licensee's patent portfolio is narrow.

These results have implications for firm boundaries in human capital intensive firms. In this paper, mergers/acquisitions, joint ventures, strategic alliances and arms-length contracts are distinguished from each other based on (a) degree of access provided to knowledge and (b) ownership rights to use this knowledge. Access provided to knowledge is full in mergers/acquisitions, high in joint ventures, moderate in strategic alliances and minimal in arms length contracts\(^3\). These choices differ based on ownership as follows. In a

\(^3\)Knowledge flows easier through social networks that get created within firm boundaries when employees in a firm work together (Kogut and Zander (1992)). Mergers/acquisitions, joint ventures, strategic alliances and arms-length contracts pro-
merger/acquisition, the acquirer owns the rights to the use its knowledge and the target’s knowledge. In joint ventures, strategic alliances and arms length contracts, each agent own the rights to use his knowledge respectively. The theory, then, predicts that when knowledge of both firms is easy (difficult) to replicate, they will choose to restrict (provide full) access to each other by choosing less (more) integrated organizational forms. In contrast, when knowledge of one firm is easier to replicate and another’s difficult to replicate, the firm whose knowledge is easy to replicate must acquire the other firm.

3 Chapter 2 – A Theory of Financing of Ideas

According to existing theory, innovators face a two step process when deciding how to finance new ideas. First, innovators decide whether to finance their ideas through a firm’s internal capital markets or through external financing (Aghion and Tirole (1994) and Gertner, Scharfstein and Stein (1994)). Then, if they choose to finance their ideas externally, they decide between corporate venture capital and independent venture capital (Hellman (2002)). In reality, however, these choices are interconnected4. This paper develops a theory to study these interconnections.

In my framework, these three modes of financing ideas differ along two dimensions: access and ownership. As in Rajan and Zingales (1998), access is defined as the ability to use, or work with, an asset5. When the asset is an idea, access implies being exposed to its intricate details. When the asset is a machine, access implies being able to operate the machine. Ownership, as in Grossman and Hart (1986), confers on the owner the rights to decide how to utilize the asset.

To understand the differences in the financing modes, think of an innovator first deciding whether to raise funds from an independent venture capitalist (VC) or a corporation and then, if the financier is a corporation, choosing between corporate venture capital and internal capital markets.

In this paper, financing by an independent VC is distinguished from financing by a corporation based on access. Access is modeled to be reciprocal – the innovator gives the same degree of access to his idea as he receives access to the financier’s assets. Reciprocal access is high in financing by corporation while it is low in independent VC financing. This is because a corporation lets an innovator use assets like research

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4 All three choices have been successfully employed to finance innovations. See literature on VC financing (Gompers and Lerner (1999), Kotrurn and Lerner (2000), Kaplan and Stromberg (2003)), external financing by corporations through strategic alliances (Lerner and Merges (1998)), and corporate venture capital (Gompers and Lerner (1998)). Innovation through internal capital markets is still dominant. Merck, for example, invests 95% of its research spending in in-house R&D and only 5% in external research laboratories.

5 Access is not the same as ownership. An agent who does not own an asset can get access to it. Thus, ownership implies access but not vice-versa.
laboratories, manufacturing facilities, distribution networks, brand name, etc. while an independent VC does not possess these assets. Reciprocally, the corporation gets to know the technical details of the innovator’s idea while a VC is typically not interested in them (Gompers and Lerner (1998)).

When a corporation finances the idea, financing through internal capital markets is differentiated from corporate venture capital financing by using ownership (Grossman and Hart (1986), Hart and Moore (1990), Hart (1995)). The corporation owns the idea when it is financed through internal capital markets while the innovator owns the idea when it is financed through corporate venture capital.

The three financing choices, defined using access and ownership, are summarized in figure 1 below. Thus, choosing the financing mode is a substitute for contracting on (a) reciprocal access and (b) ownership of the idea.

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<th>Reciprocal Access between innovator and financier</th>
<th>Who owns the Idea?</th>
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Figure 1: Definition of modes of financing ideas based on access and ownership

These different financing arrangements have efficiency consequences via their impact on the innovator and financier’s incentives to make specific investments. If they make investments to develop the idea, such investments enhance their joint surplus. If, on the other hand, the financier makes investments to replicate the innovator’s idea and thus enhance her bargaining power in the relationship, such investments are economically wasteful since they duplicate what already exists in the relationship. Similarly, investments by the innovator to reduce his dependency on the financier’s assets are economically wasteful. In my framework, all these investments are observable but cannot be verified by a court.

The trade-off governing choice of access is as follows. If the financier and innovator provide each other high access, their incentives to make investments to develop the idea are high since high access enhances the

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6 The innovator owns the idea to start with. She may already be employed with a firm or could be working independently. In either case, the innovator often has real ownership of the idea. This is because enforcement of the non-compete clauses in employment agreements has been difficult, particularly in California (Gibson (1999)). In fact, Bhide (2000) finds that 71% of the firms in the Inc 500 were founded based on ideas encountered in previous employment. Intel is a prime example of this phenomenon.

7 The case where the corporation owns the idea but gets low access to it is infeasible since ownership of the idea also confers the right to get access to it.
productivity of investments. However, high access also provides greater incentives for wasteful investments since such investments are more productive too. Thus increasing access encourages useful investments by both the financier and innovator but also leads to greater wasteful duplication by both. Decreasing access, similarly, discourages the financier and innovator's incentives to make productive and duplicative investments. Thus, changing access has a symmetric effect on the incentives of the financier and innovator.

In contrast, changing ownership of the idea has an asymmetric effect on the incentives of the financier and innovator. Consider transferring ownership of the idea from the innovator to the financier. In order to examine its effect, note that the financier's bargaining power in the relationship is determined by his outside options - his ability to develop the idea without the innovator's further involvement. Further, power over ideas accrues from having access to the idea and owning the idea (Subramanian (2005). Also see section ??). Hence the financier's bargaining power in the relationship is determined by both access to the idea and ownership of the idea. Without ownership of the idea, the financier's investments to replicate do not enhance his outside option at the margin. However, after he gets ownership of the idea, such investments are very productive and enhance the financier's bargaining power. This difference in incentives to replicate due to change in ownership is caused by the complementarity between access to the idea and its ownership. Therefore, providing the financier ownership of the idea encourages him to invest more in replicating the idea. Simultaneously, the financier's incentives to make productive investments also increase. While the financier's incentives to make productive and duplicative investments increase, the innovator's incentives to do so decrease since she loses ownership of the idea. Thus, transferring ownership of the idea from the innovator to the financier enhances the financier's incentives to make productive and duplicative investments but simultaneously dampens the innovator's incentives to do so.

Given these trade-offs, the optimal financing choice depends upon (a) the ease with which the idea can be replicated, and (b) the strength of its complementarity with existing assets. Imagine first that the innovator's idea is difficult to replicate (idea is at a later stage and hence more complex, or it is patent protected or is tacit) while the financier's assets are indispensable to the innovator (the assets are specialized and their supply is limited). In this case, the financier's investment to steal the idea is unproductive as is the innovator's investment to reduce his dependency on the financier. In this case, providing full access to each other is optimal since both the financier and innovator under-invest in developing the idea. Full access along with the innovator owning the idea (since there is no change in ownership) corresponds to corporate venture capital. Thus, when the idea is difficult to replicate and the assets required for development are
specialized, as in drugs and biotechnology (Cohen, Nelson and Walsh (1996)), corporate venture capital is optimal. Stylized facts fit this prediction: alliances between start-ups and incumbent corporations, where the start-up gets research funding from the incumbent firm, exist mainly in drugs and biotechnology (Lerner and Merges (1998)).

Now consider the case where the innovator's idea is easy to replicate (idea is early stage and so intellectual property is difficult to delineate, or patents are not well protected) while the financier's assets are not important (assets are either generic or abundantly available). In this case, both the financier and innovator have strong incentives to make duplicative investments. Since such investments do not enhance the joint output but are costly, there occurs over-investment which is socially inefficient. Therefore, in this case, minimal access is optimal. Minimal access without any change in ownership corresponds to independent VC financing. Thus, when the idea is easy to replicate (as in software since patent protection is very weak) and the assets required for development are generic (like computers), independent VC is the optimal financing choice. The dominance of VC financing in the internet and software industry, compared to other industries, is a stylized fact in line with this prediction.

Lastly, consider the case where the innovator's idea is difficult to replicate but the financier's assets are not important. In this case, the financier under-invests while the innovator has strong incentives to invest in reducing his dependence on the financier's assets. Thus, the innovator over-invests since the marginal cost of his investment is greater than the marginal increase in joint output. Transferring ownership from the innovator to the financier is optimal in this case. This is because it alleviates the financier's under-investment while simultaneously mitigating the innovator's over-investment. The financier owning the idea corresponds to internal capital markets. Thus internal capital markets is optimal when the idea is difficult to replicate and the assets required for development are generic. The Japanese consumer electronics industry (ideas are less likely to be stolen for cultural reasons and assets required in consumer electronics are generic), where firms like Sony have been able to develop ideas internally, is an approximation of this case.

The above results have implications for "a firm as a collection of existing assets and growth opportunities" (Myers (1977)). Think of the idea as a growth opportunity of an existing firm and the assets required for development as the existing assets of the firm. Given this interpretation, some growth opportunities which are difficult to replicate and need generic assets are optimally financed by its internal capital markets. A second set of growth opportunities which are easy to replicate and need generic assets, will be developed by independent VC funded start-ups. In this case the existing firm is likely to lose the idea to an independent
VC funded start-up. Bhide (2000)'s finding that 71% of the Inc 500 firms were founded by employees who encountered the ideas during their previous employment is consistent with this prediction. Finally, a third set of growth opportunities which are difficult to replicate and need specialized assets will get developed through corporate venture capital investments by a corporation. In this case, the corporation benefits partially from the growth opportunity. Thus, in this interpretation, the glue that links existing assets of a firm to its growth opportunities (Zingales (2000)) is the financing mode for developing the growth opportunity.

Existing empirical findings conform to the univariate predictions from the theory. The theory predicts that, ceteris paribus, ideas which are easy to replicate must be independent VC funded while ideas which are difficult to replicate must be funded through corporate venture capital. Gans, Hsu and Stern (2002) confirm this prediction. Using a dataset of 118 start-up companies, they find that firms with greater intellectual property protection (start-up firms having at least one patent associated with their technology) are 23% more likely to provide a license or undertake a strategic alliance with established incumbent firms than firms which have no patents associated with their technology. Also, early stage ideas are typically funded by independent VC while biotech alliances and corporate VC investments are typically later stage financing. This fact conforms to the above prediction. The second univariate prediction is that, ceteris paribus, corporate VC would be preferred to independent VC when the assets required for development are specialized. Compers and Lerner (1998) find that a corporate VC program is more successful when there exists complementarity between its existing business and those of the start-up.