Business Partnerships and the Commercialization of Inventions

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Abstract

We find that business partnership formation is very important for commercialization success of invention-based ventures. Projects run by partnerships were five times more likely to reach commercialization and had mean revenues approximately ten times greater than projects run by solo-entrepreneurs. These differences may be due both to added value from business partners and due to selection. A model shows how selection on invention quality and demand for financing can jointly arise. Empirical tests indicate strong selection into partnerships on invention quality and demand for financing. After controlling for selection effects and observed/unobserved heterogeneity, our smallest estimate of partner value added approximately doubles the probability of commercialization and increase expected revenues by 29% at the sample mean.

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1 Introduction

One important question in the entrepreneurial finance literature is the extent to which early stage financiers bring value added to start-ups. While researchers have examined the value added by institutional investors to new firms, relatively little is known about the value added from informal venture capital, a sector which by some estimates is as large or larger than the formal venture capital (VC) sector.[1]

[1] For example, Reynolds (2005) reports the informal investor sector to $162 billion per year over the period 2000-2004, while formal venture capital were reported to provide $45 billion per year to start-ups during 2000-2003. More recently, Sohl (2010), report U.S. angel investors to have provided $17.6 billion in financing for 57,225 projects in 2009. Notably, informal venture capital have different objective and modes of operation than venture capital funds. The investors typically make only a few investments at a time (on average 4 in one study), tend to invest substantially smaller amounts than VCs (about $75,000 on average in one study), invest their savings on their own or in syndication with other private persons, and they more often than VCs invest in early-stage deals. They are geographically widely distributed and make most investments locally. As opposed to institutional investors they do not, typically, rely on traditional control mechanisms such as board control, staging or contractual provisions, but rather spend time 'hands-on' in the business or exercise control through other mechanisms such as trust or social influence. Many are active investors who seek to contribute their experience, knowledge and contacts to the investee and often invest in sectors where they have had previous experience, while others are passive investors. Using a representative survey of 22,000 U.S. households, Bygrave and Reynolds (2006) show that 5% of household

This paper estimates the relative importance of informal venture capital by relying on a survey which documents the human, social, and financial capital contributions of business partners to inventive projects. The raw data from the survey shows a very important role for business partners in commercialization success; the rate of commercialization of projects run by partnerships (0.30) is five times larger than those run by solo entrepreneurs (0.06), and the revenues of projects undertaken by partnerships are almost ten times as large as those run by solo-entrepreneurs. The survey answers on the provision of human, social, and financial capital contributions, with some assumptions, allow us to identify how much of these gross effects represents the value of obtaining human and social capital while controlling for selection of projects into partnerships.

Business partnerships are important for the economy; approximately 10% of all U.S. businesses are partnerships and 18% of business receipts are from partnerships.[2] Business partners appear even more important for start-ups. For example, in the panel study of entrepreneurial dynamics, 52% of start-ups were partnerships (Ruef, Aldrich, and Carter, 2003). Reflecting conventional wisdom, the business press commonly advises entrepreneurs to partner with people in order to increase the chances to commercialize their ideas. However, the empirical evidence on the value of this advice is scattered.[3] More importantly, little is known about the mechanisms through which business partnerships are formed. Our characterization of potential partners reflect high net worth individuals, often with some prior business and/or entrepreneurial experience. We do not put any restrictions on the social relations between the partner and the original founder as prior research has shown that most informal capital investments are made in close social proximity. Business partners are assumed to join the original founder with at least one of three useful resources: financial capital, human capital, and/or social capital. These partners take on substantial risk. In our sample the average pre-revenue external investments are approximately $29,500 (2003 Cdn $), when the average probability of commercialization is 0.11.

Documenting that early stage financiers provide a real impact to start-ups has been difficult. There are several complicating factors when trying to quantify the value added of early stage financiers – self-selection and sorting being of primary concern. For instance, if inventions commercialized by partnerships have higher revenues than inventions commercialized by solo en-

are informal venture investors, 50% of their investments are received by a relative, 28.5% by a friend or neighbor, 6.1% by a colleague at work, and 9.4% by a stranger. For further descriptive evidence of the informal venture capital sector, see Harrison, Mason, and Robson (2010); Kerr, Lerner, and Schoar (2010) ; Mason (2009); VanOsnabrugge and Robinson (2000); Wong, Bhatia, and Freeman (2009); Wiltbank and Boeker (2007); and Wiltbank (2009) .

[2] Statistics of Income, http://www.irs.gov/taxstats/article/0,,id=175843,00.html The approximately 3.1 million U.S. partnerships in 2007 had 18.5 million partners. Excluding limited and limited liability partnerships (popular investment vehicles in the movie and construction industries), there were 852,000 U.S. partnerships with 3.9 million partners.

[3] Cressy (1996) and Astebro and Bernhard (2003) both report substantial effects on the survival of new firms of the number of owners.

trepreneurs it may reflect that partners provide value added in the form of human or social capital, but it may also reflect that partners join inventors with better inventions (selection on invention quality), or that inventors with better inventions, whom on average are more likely to be credit constrained, enlist partners to obtain financing (selection on demand for financing). The policy implications are vastly different depending on the answer; in the latter case one might ask if there are available policies to relax credit constraints. In the former case one might instead ask for policies to improve the efficiency of the market for finding business partners. Both policies are currently in use in Europe to stimulate business formation (Mason, 2009), but without apparent knowledge of their respective efficacy. Thus, understanding the mechanisms behind partnership formation matters both for economic policy and business strategy.

To disentangle selection effects from value added, we develop a model of invention commercialization with business partner selection. Our model describes the choice of an individual deciding whether to commercialize an invention on her own or to form a partnership. Individuals are endowed with both an invention and limited wealth. Partners can provide ability to increase the productivity of capital, and may also relax liquidity constraints. Forming a partnership involves a sunk cost. Partnership formation therefore depends on the partner's potential contribution of ability and the extent to which an inventor is liquidity constrained.

The model shows how selection on invention quality and demand for financing can jointly arise. A first result is that partners are more likely to join inventors with inventions of high quality because these inventions allow partners to obtain a higher return as compensation for their effort. A second insight is that inventors with high quality inventions - whom are more likely to be liquidity constrained - are more likely to seek partners to obtain financing. Therefore, selection into partnership can arise due to heterogeneity in the quality of inventions and the financial needs of inventors. In both cases, selection involves sorting of inventions of high quality into partnerships. Another modeling result refers to the identification of the contribution of partners' abilities. We formally show that among all potential partners the better partners are more likely to select to work with inventors because they can generate higher productivity of capital. Since partners are not randomly selected the estimable value added of those who choose to join inventors is different (the treatment on the treated) than the value added should partners be randomly selected (the treatment effect).

We test the implications of our model in reduced form regressions on data from 772 invention projects through a survey of Canadian inventors using the Invention Assessment Program at the Canadian Innovation Center (CIC) (for survey details see Astebro, Jeffrey, and Adomdza, 2007). These data reveal that in approximately 21 percent of the projects the inventor was joined by partners. The primary reason for the inventor to create a partnership was to obtain human capital (65%), followed by obtaining financing (51%), and social capital (42%), indicating a broad array of resources provided by partners.

Regression analysis show that there is selection into partnerships based on the quality of the invention and the demand for financing. To make the first point, we use two measures of pre-partnership invention quality; the invention's commercial quality as assessed by the CIC and research and development (R&D) expenditures. The high-quality assessed invention projects were twice as likely to be joined by a partner as the low-quality projects. And the average R&D expenditures were over four times larger for projects eventually joined by partners than for solo-runs. To make the second point, we test model implications stating that; a) the probability to form a partnership with financing should increase with invention quality, and b) the partnership effect should decline once controlling for the amount of external financing and c) the marginal return to external financing should be less than for internal financing. Regression analysis support all three predictions.

To examine value added we use commercialization success as our key dependent variable: the log of business revenues. Other studies have used business survival, raising of venture capital or time to IPO as proxies for business success. For this sample we believe that commercialization revenues is an appropriate measure of business success as most of these businesses have limited opportunity to raise formal venture capital or be listed on major stock exchanges, and business survival may be capturing the subjective value of staying an entrepreneur. Accounting for selection on invention quality in Tobit regressions of commercialization revenues significantly reduces the effect that forming a partnership has on commercialization success. At the sample means, partnerships increase the probability of commercialization by 16 percentage points, and increase the expected revenues by a factor of 3.5, whereas without this control the effects were approximately 22 percentage points and a factor of eight, respectively.

Three additional mechanisms may explain the remaining partnership effect: The role of commercialization investment, external financing, and labor effort. Indeed, accounting for these mechanisms reduces the partnership effect further. The remaining partnership effect, however, is still economically significant after applying these controls.

We use two alternative approaches to control for additional heterogeneity. In the first approach we control for selection on measurable inventor and invention characteristics into partnerships using a propensity score weighted Tobit model. This further reduces the size of the partnership coefficient. However, the remaining partnership coefficient still represents at least 46% of the coefficient's original size. At the sample mean, partners' ability thus increases the probability of commercialization between 0.06 and 0.09 percentage points when the probability of commercialization is 0.06 for solo entrepreneurs, and increase expected revenues by at least 29%.

In the second approach we control for unobserved heterogeneity. To do so we test an implication of our model: once controlling for the capital investment, a partner that is said to exclusively provide financing should not provide any further value added to the project. If a partnership effect remains in such a project, it must therefore indicate selection on unobservables. We can thus construct a lower bound on the value added of partner ability. Implementing this specification, we find a lower bound of partner value added providing at least a 0.06 percentage points increase in the probability of commercialization, and at least a 38% increase in expected revenues. Both approaches thus deliver the same message: the value added of partners' ability is very large.

Even after controlling for observed and unobserved heterogeneity we cannot comfortably interpret the remaining value added as a treatment effect because we do not know the abilities of the potential partners that in fact did not not join the inventors. To be able to say something more definite about the treatment effect one must compare against the abilities of a random sample of potential partners, and even in that case it is impossible to determine the treatment effect without additional assumptions because the counterfactual is never observed for the same individual (see e.g. Heckman, 1979).

Our paper is related to those examining the value added of formal venture capital to entrepreneurs and the economy. This literature tries to identify if VC financing improves business performance and innovation (Kortum and Lerner, 2000; Mollica and Zingales, 2007), and if VCs additional resources (such as a big rolodex) add value to the start-up (see Hellmann and Puri, 2000; Hellmann and Puri, 2002; Hochberg, Ljungqvist, and Lu, 2005; Chemmanur, Krishnan, and Nandy, 2009). Several papers show that the reputation of a VC acts as a signal of the quality of the venture, indicating that some VCs may be selected by entrepreneurs because they add value beyond financing (see Meggison and Weiss, 1991; Hsu, 2004; Sorensen, 2008). Hall and Lerner (2010) summarizes this literature stating that so far it has been a challenge to clearly document value added by early stage investors.[4]

The study of the effects of informal venture capital has received less attention. Closest to our paper is Kerr, Lerner, and Schoar (2010) who empirically demonstrate a positive effect of obtaining angel financing among angel financing applicants on survival and access to follow-on funding of high-growth start-up firms using a regression discontinuity approach. The intent of the regression discontinuity is to remove the potential endogeneity of funding as well as other

[4] The first paper acknowledging the possibility that venture funding and innovation could be positively related to an unobserved factor (e.g., the arrival of technological opportunities, the quality of the venture) was by Hellmann and Puri (2000).

omitted variable biases. Similarly to Kerr et al., we estimate the relative importance of early stage informal venture capital to inventive projects, and address the potential endogeneity of partnership formation. Our paper, however, differs from Kerr et al. in at least four aspects. First, we do not put any restrictions on the source of informal venture capital. Second, using two proxies of pre-partnership invention quality we control for selection into partnerships based on invention quality and demand for financing. Third, we provide a formal model of the partnering process to identify the precise effects of selection into partnerships, commercialization investments, external financing, labor effort, and value added, and to guide empirical analysis. And finally, we differ by empirically identifying the marginal effect of the partner's ability on both the probability of commercialization and expected commercialization revenues, while also purging estimation from the effects of observed and unobserved heterogeneity in two distinct ways. We think our work is complementary to theirs.

Related is also a large literature on teamwork efficiency, which analyzes bargaining issues and contract design primarily as it applies to team production in large established firms (see review by Lazear and Shaw, 2007). In this paper we abstract away from bargaining issues, which nevertheless might be important.

Our work also contributes to the literature on the choice of entrepreneurship. In a related paper, Lazear (2005) develops a theory of entrepreneurs as jacks-of-all-trades where he assumes that the entrepreneur must perform all business tasks and the choice of entrepreneurship is a strict function of his worst skill. The model we propose differs from Lazear's in that we allow individuals to add partners to obtain the required skills. Furthermore, our work is distinct to Holmes and Schmitz (1990) who develop a theory of entrepreneurship with specialization and business transfers. We focus on the process and benefits of partnerships and with good reason abstract from the possibility that the inventor may instead transfer her invention to others.[5] Finally, Evans and Jovanovic (1989) studied the degree to which personal wealth provides a binding liquidity constraint for a single individual's choice between entrepreneurship and wage work. We instead focus on individuals that already have an entrepreneurial idea and whom may find partners to relax liquidity constraints for commercial entry.

[5]We find only 5 inventors that were able to transfer their idea for cash to another entity. Those 5 are deleted from analysis.

2 A model of selection into business partnerships

The economy is populated by inventors and business partners. Inventors are endowed with a unit of labor, an invention of quality Q, and assets Z.[6] The inventor can use her unit of labor to commercialize the invention. The invention quality and assets are distributed with cdf $F_{Q,Z}$ and are independent.[7] Business partners are also endowed with a unit of time. The partner can use their unit of time to contribute complementary human and/or social capital as well as financing. The partner's social and human capital ability are randomly drawn from a cdf F_{β}. We assume that both the inventor and partner have an inelastic supply of labor and will therefore spend their unit of time in the venture. Every inventor meets a partner with positive probability. Inventions can be commercialized by the inventor on her own or with a partner. [8]

If the invention is commercialized by the inventor on her own, the profits are $V^S = QK^{\alpha} + r(Z - K)$ where K is the amount of commercialization capital invested in the business, r is the interest rate (i.e., the opportunity cost of capital), and $\alpha \in (0, 1)$. The complementarity between the commercialization capital and the invention quality implies that a higher quality of the invention will produce a higher marginal product of capital at all levels of capital. As a result some inventors may have insufficient assets to fully fund the capital investment. Following Evans and Jovanovic (1989), we consider that inventors can borrow against their assets to fund capital investment. If $Z < K$, the inventor borrows $(Z - K)$ and pays $r(Z - K)$ at the end of the period. An inventor with assets Z will be able to borrow an amount $(\lambda - 1)Z$ and invest up to $K \leq \lambda Z$, where $\lambda > 1$. Whenever the optimal capital investment is higher than the inventor's borrowing capacity the inventor will be liquidity constrained.

If the invention is commercialized with a partner, the capital is leveraged by $A(\beta)$, the partner's ability. The partner may also provide financing beyond what can be borrowed based on wealth to release an inventor's liquidity constraint. The joint profits then are $V^P = A(\beta)QK^{\alpha} + r(Z - K) - \tau$.[9] We constrain $A(\beta) \geq 1$ indicating that partners do not reduce productivity. For simplicity

[6] A sequential version of this model where inventors choose an investment level to create an invention of quality Q can be found in the appendix.

[7] In an extended version one may separately introduce the inventor's entrepreneurial ability. We do not add this complication because Q can be considered representing also the inventor's ability. In the empirical analysis we analyze the robustness of results by allowing entrepreneurial ability to vary in some specifications.

[8] We abstract away from deciding on the number of partners; our stylized partner could therefore also be interpreted as the endowments of a set of partners. We also disregard the case where the inventor directly sells the invention. Our simplified model holds for the majority of partnerships since most partnerships are between two individuals. For example, Ruef, Aldrich, and Carter (2003) shows that in the Panel Study of Entrepreneurial Dynamics, out of 421 start-ups with partners, 74% had two members, 13% had three members, 7% four, and 5% had five or more. A slightly expanded version of our model would characterize selection of multiple partners by setting the opportunity cost to nτ where n is the number of partners.

[9] Inventors are assumed to form a partnership rather than hiring employees because it is hard to write employment contracts when commercialization efforts (while observed by the contractual parties) are not verifiable by a third

we hereon reduce notation to A for partner ability, although $A(\beta)$ is some function of a vector of human and social capital. Partners' ability contribute towards a higher productivity of capital for a given level of invention quality.[10] An additional benefit of a partnership is that business partners can contribute external financing. We assume that partners are sufficiently financially endowed that partnerships can reach the unconstrained level of capital investment that maximizes profits. The parameter τ is a sunk cost to form a business partnership. We interpret it as the partner's opportunity cost to join the partnership. For simplicity, we assume that invention quality, inventor wealth, and the partner's ability are observable by the two parties.

An inventor chooses to form a business partnership if the profit from that, V^P, is higher than the profit from a solo-entrepreneurship, V^S, assuming contracting is efficient.[11] Profits are evaluated at the capital investments that maximizes their respective profits subject to liquidity constraints. If the inventor is not liquidity constrained (i.e., ($Q \leq \frac{r}{\alpha A}(\lambda Z)^{(1-\alpha)}$), the difference between V^P and V^S represents extra profits associated with a higher productivity of capital as a result of the partner's ability. These partnerships are formed exclusively to add human and/or social capital. If the inventor is liquidity constrained, the extra profits represent both higher productivity of capital (whenever partner's ability is provided) and the effect of relaxing liquidity constraints, increasing the commercialization investment to its optimal level. These partnerships may be formed to add human and/or social capital, or only to obtain external financing.

The partnership optimal decisions are illustrated in Figure 1 where invention quality (Q) is plotted against partner ability (A) for a given level of assets.[12] The figure is divided into two main regions – solo-entrepreneurship and partnership – by the threshold $\widehat{Q}^P(Z, A)$, where $\widehat{Q}^P$ is the value of Q where $V^P = V^S$. Given a partner's ability and the inventor's assets, the inventor will form a partnership if and only if the invention quality is above the threshold $\widehat{Q}^P(Z, A)$, which implies that $V^P > V^S$. The threshold $\widehat{Q}^P(Z, A)$ decreases with the partner's ability indicating that the higher the ability of the partner, the lower the invention quality needed for an inventor to be indifferent between commercializing the invention with or without a partner.

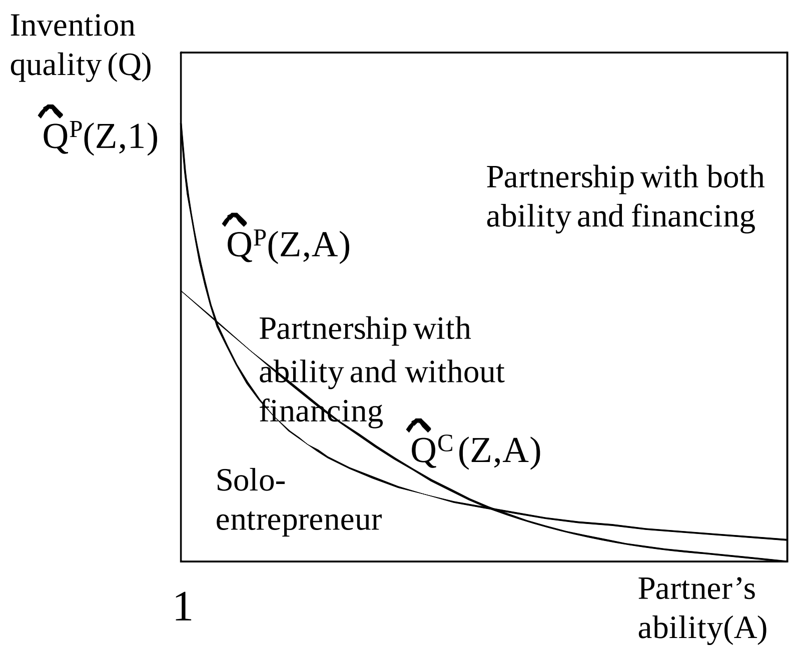
party (Grossman and Hart, 1986).

[10] An alternative interpretation is that partners leverage the quality of the invention. Both interpretations are possible, adopting the alternate does not change the comparative statics that follow.

[11] Efficient contracting implies that we are agnostic about how the surplus is split. There is no strictly preferred way to determine the division of surplus and, while it has sometimes been derived from an explicit bargaining game, it has been more common to assume that each party's share of the surplus is given exogenously. For example, in one well-known model of teamwork production, Kremer (1993, p. 585) simply notes that "the division of a firm's output among its heterogeneous workers [is] determined by a complex bargaining problem." Our model could consider potential inefficiencies associated with moral hazard problems of partnership production (see Holmstrom, 1982), but since we have no data on partnership structure, predictions from such an extension would not be testable. Instead, we assume that all inefficiencies associated with partnerships are scaled by the parameter τ.

[12] The formal proofs of the following results are in the appendix.

Figure 1: The Decision to Partner as a function of A and Q given fixed inventor assets Z



A prediction that follows from this model is that when invention quality increases, the probability to form a partnership increases. This is because a higher invention quality facilitates the amortization of the sunk costs to form a partnership. As a result, we should expect a positive correlation between pre-partnership invention quality and inventions commercialized in partnerships. A second prediction from the model is that the higher the ability of the partner that the inventor meets the higher the probability of partnership. This implies that conditional on a partnership being formed, the average ability of a partner should be strictly higher than the ability of the average potential partner. Both predictions are probabilistic because there is a probability of meeting a partner and there is ex ante uncertainty about the ability of the partner. These predictions have important implications for the estimation of value added. There will be selection into partnerships based on invention quality, and there will be selection into partnerships based on the partner's ability. Estimation of the marginal impact of the partner's ability on commercialization success must therefore control for the quality of the invention, and can only be interpreted as an average treatment-on-the-treated effect.

The region with partnership formation is further divided into two areas by the threshold $\widehat{Q}^C(Z, A)$ – partnerships with financing and partnerships without financing. $\widehat{Q}^C$ defines the quality level above which the inventor is liquidity constrained. The threshold $\widehat{Q}^C$ decreases with the partner's ability indicating that the higher the partner's ability the lower is the invention quality above which an inventor is liquidity constrained. Partnerships with ability but without financing are located in the region above $\widehat{Q}^P$ and below $\widehat{Q}^C$ in Figure 1. These partnerships do not require a partner for financing reasons, but the partner's contribution of human and/or social capital outweighs the cost of partnering. There are two characteristics about these partnerships that are worth noticing. First, partnerships with ability but without financing exist only for intermediate levels of invention quality; for higher levels of invention quality there will always be external financing as the inventor's liquidity constraint will eventually bind; and for lower levels of invention quality a partnership may only be profitable when external financing releases liquidity constraints (inventor's assets are low) and therefore partners will provide both ability and financing. Second, for the intermediate levels of quality, decreasing invention quality further may temporarily increase the proportion of partnerships with no financing while the overall proportion of partnerships may decrease, as can be seen in Figure 1. The explanation is that the relative benefit of the contribution of partners' ability holds up better than the drop in value added of external financing as invention quality diminishes.

Partnerships with both ability and financing are characterized by inventions that range from high to low levels of invention quality. The partnerships with higher level of invention quality involve external financing because the inventor's liquidity constraints are more likely to bind. Instead, partnerships of low invention quality may only be profitable when inventor's assets are low and therefore partners must provide both ability and financing. If the demand for external financing originates from these lower quality inventions, the selection effect on demand for financing will be less. These results suggest that to assess the importance of selection on demand for financing we may compare the mean invention quality in partnerships with both ability and financing against partnerships with ability but without financing. If the mean quality in partnerships with both ability and financing is lower than the quality in partnerships with ability but without financing, then the proportion of inventors with sufficiently low assets in the economy will be large and the selection on demand for financing will be less.

Finally, it is possible that if invention quality is sufficiently high a partner without ability may join simply to release credit constraints. Partnerships that provide only financing are located at the top left corner of Figure 1.

To summarize this discussion, there will be three types of partnerships; those where partners only bring financing, those where partners provide both ability and financing, and those where partners only provide ability. A first testable prediction of the model was that when invention quality increases, the probability to form a partnership increases. This implies selection on quality.

The second prediction was that the higher the ability of the partner that the inventor meets the higher the probability of partnership. This implies selection on partner ability. A third prediction was that the probability to form a partnership to obtain financing increases with invention quality. This prediction implies selection on demand for financing. However, we also showed that the mean invention quality in partnerships with both ability and financing may be lower than for partnerships with ability and without financing. This could happen if the proportion of inventors with sufficiently low assets in the economy is large and would imply that selection on demand for financing would be less.[13]

3 Data

We focus our empirical analysis on a sample of independent inventors; that is, individuals who decide to develop inventions outside their regular employment duties. Many inventors may not have great entrepreneurial or business skills and may lack the financial capital necessary to commercialize their inventions. Further, they may lack the benefits of working in a large organization in terms of access to a multitude of internal resources such as a lab, funding, skilled colleagues, and an established marketing and distribution network. They may thus find it particularly useful to have others join them in their commercialization efforts. A construction business, corner store, personal service, or restaurant (the most common start-ups), may not require large up-front investments, but commercializing new products involve using significant business skills and capital investments. Studying independent inventors should thus likely provide an excellent opportunity to examine the role of informal venture capital, partnership mechanisms, and their outcomes.

However, it is costly, given their scarcity, to find independent inventors among the general population. To economize on search costs, we therefore use a list of independent inventors, self-identified through their use of the services of the Canadian Innovation Centre (CIC). The CIC charges a fee for assessing the inventor's project. The assessment results in an overall recommendation that is either positive or negative. Our sample frame consists of inventors that had asked the CIC to evaluate their inventions between 1994 and 2001. Of these, we had current

[13] If we for the moment assume uniform distributions of assets and invention quality in the inventor population, and a uniform distribution of partner ability, the most likely type of partnership is that where partners bring both financing and abilities. However, skew or bimodal distributions of quality, assets or ability in the economy may temper this prediction. An additional conclusion from the model is that the pool of solo-entrepreneurs will consists of two types; those with low quality inventions which are not liquidity constrained and those with higher quality which are liquidity constrained but which did not find a suitable partner. The fraction of liquidity constrained solo-entrepreneurs as well as the fraction of partnerships varies across economies as a function of the preponderance of potential partners (with financing and abilities) in the economy, and the distribution of invention quality and assets in the inventor population.

addresses for 1,770 which we contacted by surface mail in 2004. We were then able to contact 934 by telephone, and from these we obtained 830 telephone surveys. All data except the invention evaluations are self-reported. We remove 53 partially answered surveys and 5 observations where the IP was sold or licensed, leaving 772 observations for analysis. Missing item responses were imputed five times assuming data were Missing At Random (MAR) using a switching regression approach described in van Buuren et al. (1999), where missing data were randomly replaced conditional on observed data and survey structure. Means, coefficient estimates and standard errors are subsequently computed over five complete datasets using the formulae in Little and Rubin (1987, equations 12.17–12.20).[14] Pseudo-R^2's are provided for one of the five samples as an indication of absolute levels.

The data primarily contains information on pre-CIC research and development (R&D) expenditures, pre-partnership invention quality assessment by the CIC, post-CIC commercialization expenditures, a dummy for the creation of a partnership to commercialize the invention, three non-exclusive dummies for the type of capital partners bring (human capital, social capital, and financing), the amount of external financial capital, whether or not the invention was commercialized, total commercialization revenues, and year and industry classification codes. There are also sundry inventor and invention characteristics in the survey that we employ when computing partnership propensity scores.

3.1 Summary statistics

The modal inventor age is 45-54 and the modal educational attainment is high school, although about 26% of the inventors had some professional or graduate education. While the identification of inventors relies on a specific, focal, invention submitted to the CIC it does not imply that the individuals are predominantly one-shot inventors. To the contrary, the sample is dominated by long-term serial inventors. Fifty-three percent of them had spent six or more years developing inventions, and 75% had worked on more than one invention. Eleven percent developed the invention as part of their normal duties at work. Twenty-six percent were stimulated by something at work, a majority of which (73%) were not required to innovate at work. Descriptions of some inventions reveal most to be “user-driven”. The sources of invention are thus quite varied.

[14] In multiple imputation, missing values for any variable are predicted using existing values from other variables. The predicted values replace missing values, resulting in a full data set. This process is performed multiple times. Standard statistical analysis is performed on each imputed data set. Results are then combined. Multiple imputation restores not only the natural variability in the missing data, but also incorporates the uncertainty caused by estimating missing data. Uncertainty is accounted for by creating different versions of the missing data and observing the variability between imputed data sets. For a further introduction to missing imputation see Graham and Hofer (2000).

Only 16% reported they were unemployed, home-makers, retired, disabled, or on sick leave during the time that they were developing their focal invention. Most (58%) were full-time employees, while 32% were self-employed when developing their invention (multiple answers possible). The median invention development effort on the focal invention was performed in 1997, and 95% of respondents had attempted to develop their focal invention before 2003.

With regards to the inventions, 21% were rated as of high quality by the CIC and given a positive recommendation, suitable to develop further at least as a part-time effort. The other 79% were deemed of low quality and inventors were recommended to stop further development. Most numerous were sports/leisure products (28%), followed by 16% security or safety applications, 14% automotive, 14% medical or health, and 13% which had environmental or energy applications. Inventions involving high technology (9%) and industrial equipment (14%) were also relatively frequent. Successful consumer-oriented inventions included a new milk container design, a washable sanitary pad, and a home security light timer that imitates typical use. Other inventions had business applications. These inventions included an aligner and printer for photographic proofs, a tractor-trailer fairing that enhances fuel efficiency, a re-usable plug to insert in wooden hydroelectric poles after testing for rot, and a computerized and mechanically integrated tree harvester. Thus, the inventions varied substantially in technological complexity and market potential.

The pre-commercialization investments in the inventions reveal to be far larger than in the ordinary start-up. For example, the 1992 Characteristics of Business Owners database report that the majority of U.S. start-ups (approximately 60%) were started or acquired with no cash outlay or with less than $5,000 (U.S. Department of Commerce, 1997.) In contrast, the average R&D investment for the inventors is approximately Cdn. $22,500 and the additional commercialization investment is another Cdn. $24,800 (2003 values). Nevertheless, investments in these projects at the same time appears somewhat less than those undertaken by 'business angel networks'. For example, Wiltbank and Boeker (2007) report the average investment size per project (including follow-on investments) by business angel networks to be $191,000 (median investor contribution $50,000), while Wiltbank (2009) report an average investor contribution of £42,000. Note that the samples of projects with business angel investors are constructed conditioned on business angel investments being positive, while our sample does not have this restriction.

4 Partnerships and the commercialization of inventions

We first report some descriptive statistics on partnerships and solo-entrepreneurs. In approximately 21% of the projects the inventor was joined by someone to commercialize the invention. The primary reason for the inventor to create a partnership was to obtain human capital (65%), followed by obtaining financing (51%), and social capital (42%).[15] Figure 1 suggested four potential choices for an inventor: no partnership; partnership with only financing provided; partnership with financing and ability provided; and finally partnerships with only ability provided by the partner. Table 1 can be used to compute the proportions of these outcomes. As stated above, 79% are without a partnership. Among the partnerships, in 16% of the cases there were only financing provided, in 51% there were both financing and ability provided by partners, and in 45% of the partnerships there were only ability provided.

The fact that a significant number of inventors are joined by someone to commercialize their invention suggests that there may be benefits to partnership. Indeed, we find that working with partners is positively correlated with the probability that inventions are commercialized. Table 1B shows that partnerships have a probability of commercialization of 0.30, which is about five times larger than that of projects run by solo-entrepreneurs (0.06). The presence of partners is also positively correlated with revenues. Projects run by solo-entrepreneurs had mean present value of revenues of $24,196; mean revenues from projects run by partnerships were approximately ten times as much; $232,397. While solo entrepreneurship dominates the data there appears to be enough variation to examine partnership selection mechanisms and benefits. Importantly, not all partners provide financing indicating a potential value added effect through human and/or social capital.

4.1 Selection into partnership

Selection on invention quality The theoretical model predicts a positive correlation between pre-partnership invention quality and the probability of partnership formation. To investigate selection on invention quality, we classify inventions into two categories; high quality inventions will be those with a CIC positive assessment, the rest of the inventions are deemed of low quality. It is immediately apparent that partners are more likely to join inventors with

[15] We asked the inventor "Did you ever team up with other people trying to commercialize the invention?", if yes, we further inquired: "Why did you team up with other people?" with the following options read: "You needed to have your skills complemented by their skills", "They had contacts that were useful", "You needed the capital they provided", "They had resources that were useful (land, equipment, plant)" and "Other". In analysis the two categories prior to "other" are collapsed into one. The questions imply that there is some form of matching where the partner provides something which the inventor does not have.

Table 1: Commercialization, Invention Quality, R and D Expenditures and Revenues by Solo-entrepreneurs and Teams.

The sample consists of 772 inventions from inventors that had asked the Canadian Innovation Center (CIC) to evaluate their inventions between 1994 and 2001. The table is divided into three parts. Panel A describes the percentage of inventions that were commercialized in partnerships, and the percentages of partnerships where partners provided only financing, both financing and ability, or only ability. Panel B presents characteristics of inventions commercialized by partnerships and solo-entrepreneurs. These characteristics are: the percentage of inventions with a positive CIC assessment; the probability of commercialization; and the means of the R and D expenditures, the commercialization investment, and the commercialization revenues. Panel C presents characteristics of projects conditional on commercialization. All data are in Cdn 2003 dollars. Each missing item response has been imputed five times following van Buuren et al. (1999). Means are computed using the formulae in Little and Rubin (1987).

A. Percentage of projects with partnerships and contributions by partners

Percentage partnerships (%)	21.0
Contributions among partnerships (%)	
Only financing	15.6
Both financing and human/social capital	35.6
Only human/social capital	45.6

B. Characteristics of projects unconditional on commercialization

	All	Partnership	Solo-entrepreneur
Percentage with positive CIC review (%)	21.5	35.5	17.8
Mean R&D expenditures ($) by inventor prior to the CIC review	22,518	90,364	4,725
Mean commercialization investment ($)	24,823	70,690	12,792
Mean commercialization revenues ($)	67,432	232,397	24,196
Probability of commercialization (%)	10.9	29.9	5.9

C. Characteristics of projects conditional on commercialization

	All	Partnership	Solo-entrepreneur
Percentage with positive CIC review (%)	49.3	55.0	41.7
Mean R&D expenditures ($) by inventor prior to the CIC review	166,009	282,354	10,882
Mean commercialization investment ($)	110,343	169,732	31,158
Mean commercialization revenues ($)	619,739	776,238	411,073

Table 2: Probit Regression Analysis of Partnership

The sample consists of 772 inventions from inventors that had asked the Canadian Innovation Center (CIC) to evaluate their inventions between 1994 and 2001. The dependent variable is partnership, a dummy variable taking the value 1 if an innovation was commercialized as a partnership, 0 otherwise. The independent variables are "Positive", a dummy variable taking the value 1 if the CIC assesment was positive, 0 otherwise; and "R and D expenditures", the natural logarithm of R and D expenditures. All data are in Cdn 2003 dollars. All regressions include dummy variables controlling for the project's industry, and the year the invention was assessed by the CIC. Standard errors in parenthesis. ***, ** or * mean the coefficient is significant at the 1 percent, 5 percent, or 10 percent level, respectively. Each missing item response has been imputed five times following van Buuren et al. (1999). Coefficients and standard errors are computed using the formulae in Little and Rubin (1987).

Parameter estimates of effects of invention quality			
Positive	0.397***		0.211
	(0.130)		(0.142)
R&D expenditures		0.080***	0.071***
		(0.016)	(0.017)
Pseudo $R^2(\%)$	0.06	0.08	0.08
N	772	772	772

high quality inventions, as shown in Table 1B. Partnerships are twice more likely to have high quality inventions than solo-entrepreneurs, 35 percent versus 18 percent. Stated differently, 34 percent of inventions rated as high quality were eventually joined by a partner, while only 17% of inventions with low quality were joined by a partner. We have also classified the quality of the inventions using the inventor's own research and development (R&D) expenditures prior to the CIC assessment and partnership formation.[16] Partners were more likely to join inventors with higher R&D expenditures. The average R&D expenditures by the inventors that were eventually joined by partners was $90,364; the solo-entrepreneurs spent on average $4,725. To control for varying capital requirements by technology and for varying costs of capital we include industry and year dummies in a regression of the probability of partnership formation on invention quality. Estimates survive the inclusion of these industry and year controls (see Table 2). The Table also reveals that inventors' R&D expenditures were correlated with the CIC assessments.

Selection on demand for financing An additional reason for why partners join inventors is to provide external financing. The model provides several predictions concerning the interplay of external financing and partnership formation. A first prediction is that the probability to form a partnership to obtain financing increases with invention quality. Using the same quality indicators

[16] We separate between the idea creation and commercialization phase by the date of the CIC assessment.

Table 3: Probit Regression Analysis of Partnership with Financing

The sample consists of 772 inventions from inventors that had asked the Canadian Innovation Center (CIC) to evaluate their inventions between 1994 and 2001. The dependent variable is partnership with financing; a dummy variable taking the value 1 if an innovation was commercialized by a partnership with financing, 0 otherwise. The independent variables are Positive; a dummy variable taking the value 1 if the CIC assesment was positive, 0 otherwise; and the natural logarithm of R and D expenditures. All data are in Cdn 2003 dollars. All regressions include dummy variables controlling for the project's industry, and the year the invention was assessed by the CIC. Standard errors in parenthesis. ***, ** or * mean the coefficient is significant at the 1 percent, 5 percent, or 10 percent level, respectively. Each missing item response has been imputed five times following van Buuren et al. (1999). Coefficients and standard errors are computed using the formulae in Little and Rubin (1987).

Parameter estimates of effects of invention quality			
Positive	0.125		-0.029
	(0.152)		(0.165)
R&D expenditures		0.055***	0.057***
		(0.019)	(0.021)
Pseudo R^2(%)	0.05	0.06	0.06
N	772	772	772

and controls as before as predictors, Table 3 presents Probit regressions with a dummy = 1 if a partnerships was formed to obtain financing, and zero otherwise. The table shows support for this prediction. It appears that most of the invention quality variation that determines partnership financing is best captured with pre-partnership R&D expenditures.

Another prediction refers to the invention quality where partners provide both ability and financing versus the quality where partners provide only ability. According to our theory, partnerships with both ability and financing can have lower average invention quality than partnerships with only ability only if the proportion of inventors with low assets is high. Data show that partnerships with both ability and financing indeed have a lower proportion of positive CIC assessments (30%) and R&D expenditures (Cdn $18,775) than partnerships with only ability (41% and Cdn $177,025, respectively). The differences are statistically significant (t-tests of differences in proportions and means are 3.32 and 3.60, respectively.) This result suggests that the proportion of inventors with low assets may be large. It implies that selection on demand for financing may be less since the demand for financing may be primarily from lower quality inventions. Once we analyze value added we can test additional predictions relating to the demand for financing.

5 The value added of partners' ability

To study the contribution of partner in the commercialization of innovations we adopt the following econometric specification:

$$y_i = \left\{ \begin{array}{ccc} y_i^* & \text{if} & y_i^* > 0 \\ 0 & \text{if} & y_i^* \leq 0 \end{array} \right\}$$

with y_i^* as a latent variable indicating commercialization success, and

$$y_i^* = \alpha q_i + \beta d_i + \delta X_i + \mu_j + \tau_t + e_i$$

where y_i is the log of commercialization revenues; q_i is unobserved (to the econometrician) invention quality; d_i is a dummy that equals one if a partnership was formed to commercialize invention i; X_i represents regressors that vary across inventions, and e_i is a normally distributed zero mean residual component. The terms μ_j and τ_t correspond to industry and CIC application year effects as implemented by a set of dummy variables, and β captures the effect of partner's ability on the commercialization revenues conditional on a partnership being formed.[17] We use the log form to allow for multiplicative effects of inputs as posited by our theoretical model.

Table 4 reports the effect of forming a partnership and control variables on the latent variable y_i^*. We use a Tobit model as there are a large number of inventions that are never commercialized and have zero revenues.[18] To provide intuition, we use a standard decomposition technique of the coefficient β into the marginal effect on the probability of commercialization, and the marginal effect on expected log revenues, both estimated at sample means (see e.g. McDonald and Moffitt, 1980).[19] The first column (Model 1) shows the estimated coefficient for the partnership dummy controlling for industry and year effect. Joint t-tests indicate that industry dummies (t=1.74) and year dummies (t=1.70) are only marginally significant. After controlling for industry and year dummies the size of β is 15.25. Taking this value and evaluating the marginal effects of partnership at the mean of the sample imply that an invention project run as a partnership has

[17]See Proposition 4 in the appendix for proof that β must be interpreted as a treatment-on-the-treated effect.

[18]We also experimented with a Heckman selection specification, but we could not find a variable that could be reasonably assumed to affect the probability to commercialize but not revenues conditional on commercialization. Without an exclusion restriction estimations were very unstable or did not converge.

[19]Consider the following Tobit model. Let the dependent variable be $y = y^*$ (if $y^* > 0$) and $y = 0$ (if $y^* \leq 0$), and the latent variable $y_i^* = \beta X + e_i$. The marginal effect on the observed log of expected revenues y is $\frac{\partial E(y|X)}{\delta x_k} \beta_k \Phi(\frac{X\beta}{\sigma})$, where x_k is a regressor of interest, $\overline{X}$ is a matrix of the sample means of the regressors, β_k is the corresponding Tobit estimated coefficient of the regressor x_k, and Φ is the cdf of the standard normal distribution. If x_k is a dummy, the marginal effect is the difference between the difference of the predicted values of of the dummy evaluated at the sample mean of the rest of the regressors. Because our dependent variable is the log of revenues, the marginal effect of partnership in revenues can be approximated by exponentiating the marginal effect of partnership on the log of revenues.

approximately a 0.22 greater probability of commercialization than one run by a solo-entrepreneur, and its expected revenues are eight times higher than a solo-entrepreneur project. (Since the controls are only marginally significant the gross differences in Table 1B are quite similar; 0.24 and 9.6, respectively.)

The positive correlation between commercialization success and partnership formation has to be interpreted with caution. We previously showed that partners are more likely to join inventions of higher quality and that the demand for financing depends on invention quality and thus also determines partnership formation. Both findings indicate that the partnership coefficient in Column 1 is endogenously determined and likely upwards biased.

We therefore add two proxies to account for selection based on invention quality: the CIC assessment and the log of R&D expenditures. The second column in Table 4 (Model 2) shows that the effect of partnership formation on expected commercialization success then decreases from 15.25 to 11.68, a 23 percent reduction. The test indicates that there is clear selection on project quality into partnerships. However, the partnership coefficient still remains significant and large. At the sample means, partnerships are associated with an increase in the probability of commercialization of 16 percentage points, and an increase in the expected revenues by a factor of 3.5. The large magnitudes of these effects indicate additional partnership effects.

Two additional mechanisms may explain the remaining partnership effect — the role of commercialization investments and external financing. Our theory suggests that optimal commercialization investments should increase whenever the partner's ability increases the productivity of capital. If partner's ability increases the productivity of capital, controlling for the commercialization investment should account for the part of the partnership effect that causes an increase in the optimal investment level. In addition, the amount of external financing provided by partners should capture the partnership effect on revenues from relaxing liquidity constraints. Unfortunately, due to survey structure we cannot simultaneously identify these two effects.[20] We therefore run two regressions where we first analyze the impact of commercialization investments and then analyze the impact of external financing.

In Model 3 of Table 4 we analyze the effect of commercialization investments. The third column adds the natural logarithm of post-partnership commercialization investments; the sum of all cash

[20] The survey enquired: 1. First, we would like to know how much money was spent on developing XX. Include all costs for product development, marketing research, making of prototypes, etc. How much did you spend before you contacted the CIC for an evaluation? 2. How much did you spend after you contacted the CIC for an evaluation? 3. I will now read a list of sources of funds that you may have used to pay for the costs of developing your invention. Please tell me for each source whether you have actually used it or not. 4. Consider the total amount of money you have spent on this invention so far. How large a proportion of this amount was your own money? These data allow us to identify either the effect of commercialization investment (using question 2) or external financing (using question 4).

provided both by the inventor and external financiers to commercialize the invention after the formation of a partnership. The results show that the commercialization investment is affected by partners contributing ability because the partnership coefficient declines significantly (35.5%) when adding the commercialization investment. But while the introduction of commercialization investment reduces the partnership coefficient considerably, the partnership effect remains positive and statistically significant. For instance, evaluating the effects of partnerships at the mean of the sample, partnerships increase the probability of commercialization by 8 percentage points, and increase expected revenues by 65%. Another noteworthy results is that both the quality indicators diminish in size and significance once we control for commercialization investment. The reason is that the commercialization investment is also endogenous to project quality: optimal investments increase with invention quality.

To examine whether inventors are liquidity constrained and the degree to which partners relax these liquidity constraints, in Table 5 we separate between the natural logarithm of the inventor's cash contribution and the natural logarithm of the sum of all cash contributions by all external financiers.[21] A first result from this analysis is that the size of the coefficient for external financing is almost four times lower than the coefficient for own financing in Model 3. This result is consistent with the idea that inventors are capital constrained. If they were not constrained the coefficients for internal and external financing should be equal.[22] Thus, selection into partnerships to release liquidity constraints is likely to occur. External financing is also positively correlated with the partnership effect, but not very much. Quantitatively, the partnership coefficient is reduced from 10.28 (in model 2) to 9.26 (in model 3), a reduction by 10%. The results indicate that partners may often not be the main external financier.

Our theoretical model assumed that labor supply was inelastic both for the inventor and the partner. But it is possible that labor may be supplied elastically. The inventor may for example be trading off time in the venture with working part-time as an employee and the partner may be investing in several ventures at the same time. We therefore relax the assumption of inelastic labor supply in Model 4. In particular, we inquired about the sum of the number of hours provided by the inventor and all partners post CIC evaluation to commercialize the invention. Including the log of this number (with log of zero hours set to zero) will allow us to approximately isolate partner ability from hours of input by the partner. Results are reported in Model 4 in Tables 4 and 5. Controlling for labor inputs, the partnership coefficient drops by 0% in Table 4 and 5% in Table

[21] All others may be for example banks, family, friends, business partners, universities as well the government. Due to survey structure we could not separate the investments between these external suppliers of capital.

[22] This result is consistent with the finding that smaller and younger firms have higher growth-cash flow sensitivities than larger and more mature firms (see e.g. Fazzari, Hubbard, and Peterson, 2000).

5. The low conditional correlation between the partnership dummy and total hours indicate that it is the inventor whom perform the majority of commercialization efforts, and that the main contribution by partners is skills, rather than hours. However, the magnitudes of the other parameters generally drop, indicating that labor efforts are positively correlated with invention quality, total commercialization investments, and the amount of external financing. Nevertheless, the partnership coefficient remains significant and large.

Whatever is left of the partnership coefficient after accounting for selection on quality, commercialization investment, labor supply, and external financing can be attributed to the partner's ability, but as well to measurement error and model mis-specification. In the next two subsections we therefore attempt to further control for selection on inventor-invention characteristics, selection on unobservables and measurement error of invention quality to isolate the value added effect of partner ability on commercialization success.

5.1 Accounting for selection on observables

We start by controlling for selection into partnerships on observable inventor characteristics using a propensity-score weighted model described by Hirano, Imbens, and Ridder (2003).[23] Woolridge (2007) discuss a related approach, but Hirano et al.'s method may produce more efficient estimates. We estimate the propensity to form a partnership with logistic regression using as predictors the previously used variables: Positive, pre-partnership R&D expenditures, industry and year dummies, as well as a range of additional pre-determined pre-partnership inventor and invention characteristics to calibrate the propensity to form a partnership.[24] The range of inventor and invention characteristics is quite large. Matching partnership observations to non-partnership observations with similar propensity scores we can behave as if there was random assignment to partnerships on inventor and invention characteristics, under the condition that there is ample

[23] In another attempt to endogenize partnership formation we estimated an IV model with "the invention was stimulated at work" as exogenous predictor of partnership. It seems reasonable to presume that if the stimulus for the invention was at work it may make it easier for the inventor to find partners, but should not necessarily directly affect returns. The variable indeed was a significant predictor of partnership ($t=2.94$, $p<0.01$) and the J-test confirmed that it was not correlated with the error term of the outcome regression (Chi-2=0.09 and 0.06, $p>0.10$.) Although the instrument is valid and reliable the results were not stable. This is a situation where the instrument simply is too weakly identified.

We also experimented with including all the inventor and invention characteristics in the production function. This produced results qualitatively similar to the ones reported in Tables 4 and 5 and were deemed to be of no major interest. Results available on request from the corresponding author.

[24] We included inventor gender, marital status, age, education, work experience, managerial experience, business experience, family business experience, years experience inventing, number of inventions developed, invention developed at work, invention stimulated at work, invention developed together with someone else, full-time, part-time, un- or self-employed when inventing. We also included the following invention characteristics: positive, pre-team R&D expenditures, pre-team number of hours of effort, industry dummies, year dummies, and whether the fee paid to the CIC for the review was partly subsidized by a third party.

Table 4: Tobit Regression Analysis of Commercialization Revenues

This Table presents latent variable results from Tobit regressions. The dependent variable is the natural logarithm of commercialization revenues. The independent variables are; partnership: a dummy variable =1 if an inventor formed a partnership to commercialize the innovation and 0 otherwise; partner with ability is a dummy =1 if the inventor formed a partnership and the partner contributed human and/or social capital and 0 otherwise; partner without ability but with financing is a dummy variable =1 if the inventor formed a partnership and the partner contribute financing but did not contribute neither human nor social capital; Positive, is a dummy variable =1 if the CIC assesment was positive, 0 otherwise; and R and D expenditures, and commercialization investment are the natural logarithms of R and D expenditures and commercialization investment, respectively. All data are in Cdn 2003 dollars. All regressions include dummy variables controlling for the project's industry, and the year the invention was assessed by the CIC. Standard errors in parenthesis. ***, ** or * mean the coefficient is significant at the 1 percent, 5 percent or 10 percent level, respectively. Missing item data are multiple imputed using switching regression and assuming data are MAR. Coefficient estimates and standard errors are constructed using the formulae in Little and Rubin (1987).

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
	Tobit	Tobit	Tobit	Tobit	Propensity Score Weighted Tobit	Tobit
Partnership effects						
Partnership	15.25***	11.68***	7.54***	7.54***	7.06***	
	(2.38)	(2.14)	(1.94)	(1.92)	(1.84)	
Partner with ability						7.09***
						(2.01)
Partner without ability but with financing						6.52*
						(3.69)
Control variables						
Positive evaluation		5.44***	3.02	3.05	2.19	3.11
		(2.15)	(1.98)	(1.98)	(1.94)	(1.98)
R&D expenditures		1.57***	0.54*	0.48	-0.30	0.49
		(0.35)	(0.33)	(0.33)	(0.29)	(0.33)
Commercialization investment			1.61***	1.14***	1.00***	1.19***
			(0.28)	(0.31)	(0.31)	(0.32)
Commercialization labor				1.05**	1.32***	1.01**
				(0.44)	(0.48)	(0.44)
Constant	-25.07***	-34.22***	-31.78***	-32.71***	-25.76***	-32.17***
	(4.70)	(5.43)	(4.98)	(5.05)	(4.49)	(4.98)
Sigma	14.88***	13.37***	11.97***	11.81***	9.51***	11.87***
	(1.44)	(1.28)	(1.13)	(1.11)	(0.91)	(1.12)
Pseudo $R^2(\%)$	0.09	0.13	0.18	0.19	0.14	0.18
N	772	772	772	772	724	772

partnership and non-partnership observations for each score. We examined this requirement and deleted 48 observations where there was no common support, leaving 724 observations for subsequent analysis. The region of common support for the score is [.02, .91], capturing the 1st to the 99th percentile. Because there is considerable overlap in the score distributions between partnership and non-partnership observations between the 1st to the 99th percentile the so-called balance property is satisfied and we can safely rely on the scores to provide reasonable matching.

Results of the inverse propensity-score weighted Tobit are provided in Model 5. As seen, the estimate of the partnership coefficient is again reduced, indicating that there is also selection on observable inventor and invention characteristics. The coefficient however does not decrease that much, it drops by an additional 6.3% and 9.7%, in Tables 4 and 5 respectively. Therefore, after controlling for these selection effects, the partnership coefficient still remains large. The size of the effect is either 46% or 52% of the gross partnership coefficient in Model 1, respectively. The estimate from Table 4 implies that expected revenues of commercialized inventions increase by 29% going from solo-entrepreneurship to partnership, and that the probability of commercialization increases by 0.06 percentage points, which is a 97% percent increase over the commercialization rate of solo-entrepreneurs, both non-trivial impacts (at the sample means of other variables). The estimates of the impact of partnerships from Table 5 are somewhat stronger. Partnerships increase the probability of commercialization by 0.09 percentage points, and increase expected revenues by 49% (at the sample means of other variables).

Another result to note is that once we control for inventor and invention characteristics prior to collaboration, the coefficient for own financing becomes negative. This may be the case because our propensity score method uses observables that are correlated with the borrowing capacity of the inventor.

5.2 Accounting for selection on unobservables

Finally, we address the possibility that there is inventor-invention unobserved heterogeneity and measurement error of our identified selection effects. Here we utilize the fact that some partners only provide financial capital. We decompose the partnership effect as follows: Partnership = partner with ability $[P(a)]$ + partner without ability but with financing $[P(not\_a\_fin)]$. A result of our theoretical model is that the financial contribution of partners exclusively affect commercialization investments by relaxing liquidity constraints. An implication of this identifying restriction is that once we control for invention quality and commercialization investment, a partner that exclusively provides financing should not affect revenues in any other way, i.e., the coefficient for $P(not\_a\_fin)$ should be zero ($\gamma = 0$). If the estimated coefficient for $P(not\_a\_fin)$ is zero,

Table 5: Tobit Regression Analysis of Commercialization Revenues with Inventor's and Other's Capital

This table presents results from Tobit regressions. The dependent variable is the natural logarithm of commercialization revenues. The independent variables are partnership, a dummy variable =1 if an inventor formed a partnership to commercialize the innovation and 0 otherwise; partner with ability is a dummy variable =1 if the inventor formed a partnership and the partner contributed human and/or social capital and 0 othewise; partner ability but with financing is a dummy variable =1 if the inventor formed without a partnership and the partner contribute financing but did not contribute neither human nor social capital; Positive, which is a dummy variable =1 if the CIC assesment was positive, 0 otherwise; and own financing and other financing are the natural logarithms of the total R and D expenditures and the total commercialization investment from the inventor and the partner, respectively. All data are in Cdn 2003 dollars. All regressions include dummy variables controlling for the project's industry, and the year the invention was assessed by the CIC. Standard errors in parenthesis. ***, ** or * mean the coefficient is significant at the 1 percent, 5 percent, or 10 percent level, respectively. Missing item data are multiple imputed using switching regression and assuming data are MAR. Coefficient estimates and standard errors are cosntructed using the formulae in Little and Rubin (1987).

	Model 2	Model 3	Model 4	Model 5	Model 6
	Tobit	Tobit	Tobit	Propensity Score Weighted Tobit	Tobit
Partnership effects					
Partnership	10.28***	9.26***	8.83***	7.98***	
	(2.08)	(2.08)	(2.02)	(1.92)	
Partner with ability					8.45***
					(2.10)
Partner without ability but with financing					6.66*
					(3.81)
Control variables					
Positive evaluation	5.03***	4.30**	4.29**	4.02**	4.31**
	(2.06)	(2.05)	(2.02)	(2.05)	(2.03)
Own financing	1.90***	1.74***	0.81**	-0.56*	0.86**
	(0.36)	(0.36)	(0.37)	(0.28)	(0.37)
External financing		0.43**	0.22	0.40*	0.25
		(0.22)	(0.21)	(0.22)	(0.22)
Commercialization labor			1.73***	2.13***	1.70***
			(0.44)	(0.46)	(0.44)
Constant	-36.38***	-35.37***	-33.67***	-24.01***	-33.22***
	(5.54)	(5.42)	(5.17)	(4.50)	(5.12)
Sigma	13.02***	12.83***	12.31	9.22***	12.39***
	(1.24)	(1.22)	(1.17)	(0.88)	(1.18)
Pseudo R^2(%)	0.15	0.15	0.17	0.12	0.17
N	772	772	772	742	772

$\widehat{\gamma} = 0$, then the coefficient for $P(a)$ (label this $\widehat{\beta}$) should represent the partner's estimated value added. Alternatively, if $\widehat{\gamma}$ is positive, then there will likely be selection on unobservables and therefore $\widehat{\beta}$ may have an upward bias.

Model 6 in Tables 4 (5) replaces Partnership with dummies for $P(a)$ and $P(not\_a\_fin)$. In Table 4 we find that $\widehat{\beta} = 7.09$ ($p < 0.01$), and $\widehat{\gamma} = 6.52$ ($p = 0.08$). Results in Table 5 are similar. Therefore, it appears that $\widehat{\beta}$ is upwards biased due to selection on unobservables.

We proceed to separately identify the contribution of the partner's ability from selection on unobservables. Rather than imposing further parametric restrictions to obtain point identification, we construct a lower bound for $\widehat{\beta}$. The effect of selection on unobservables may differ between partners who provide abilities and partners who only provide financing. Indeed, Figure 1 shows that conditional on inventor's assets the partnerships that receive only financing ($A = 1$) have on average higher quality inventions than the rest of the partnerships. An implication of this result is that the higher the quality of an invention, the more likely it is that a partnership with only financing will be formed. This is equivalent to that $cov(P(a), Q) < cov(P(not\_a\_fin), Q)$. The sign of this inequality allows us to calculate a lower bound of the partner's ability: $\beta^L = \widehat{\beta} - 0.224\widehat{\gamma}$.[25] Evaluating the right hand side of the bound at the estimated $\widehat{\beta}$ and $\widehat{\gamma}$, we obtain $\beta^L = 5.63$ (std. err. $1.99, p < 0.00$) and $\beta^L = 6.95$ (std. err. $2.06, p < 0.00$) for the estimations presented in Table 4 and Table 5, respectively. Because we can safely assume that an upper bound for β is $\widehat{\beta}$, the best estimate of partner's ability must lie in the range $\beta \in (5.63, 8.45)$. The lower bound represents a partnership coefficient that is lowered from 7.54 in Model 4 to 5.63 in Model 6 of Table 4, a 25% reduction. The lower bound is 37% of the gross partnership coefficient in Model 1. The lower bound remains economically meaningful. For example, the mean probability of commercialization increases from 0.06 to 0.12 at the estimated lower bound value added, and the effect on expected revenues is a 38% increase. As the lower bound estimate is higher for results in Table 5 we refrain from reporting those details. Note that this method returns estimates quite similar to those from the method controlling for observed heterogeneity.

6 Conclusion

We investigated the value of informal capital for invention commercialization through business partnership formation. Partnerships are defined as when an inventor partners with someone to

[25] Define $bias(\widehat{\beta}) = \frac{cov(P(a),Q)}{Var(P(a))}$ and $bias(\widehat{\gamma}) = \frac{cov(P(not\_a\_fin),Q)}{Var(P(not\_a\_fin))}$. $bias(\widehat{\gamma}) = \widehat{\gamma}$ since our theoretical model implies that the true value of γ is 0, while $bias(\widehat{\beta}) = \widehat{\beta} - \beta$. Rearranging and using that $Cov(P(a), Q) < Cov(P(not\_a\_fin), Q)$, the lower bound β^L for $\widehat{\beta}$, is $\beta^L = \widehat{\beta} - (\frac{Var(P(not\_a\_fin))}{Var(P(a))})\widehat{\gamma} = \widehat{\beta} - 0.224\widehat{\gamma}$. We have replaced $Var(P(a))$ and $Var(P(a\_not\_a\_fin))$ with their sample counterparts.

obtain human capital, social capital and/or financing to attempt commercializing an invention.

We develop a model of invention commercialization with partnership formation which reveals three selection effects. We show that partners are more likely to join inventor-inventions of high quality because these inventions allow them to obtain a higher return as compensation for their effort. A second insight is that among all potential partners the better partners are more likely to join inventors. Lastly, inventors with high quality inventions are more likely to be liquidity constrained and consequently more likely to seek partners for financing.

Raw data reveal that the effect of partnerships on project outcomes is considerable. The rate of commercialization of inventions run by partnerships is five times larger than those run by solo entrepreneurs and revenues are almost ten times as large for partnerships as for solo entrepreneurs. The data reveal selection into partnerships based on invention quality: 33% of inventions rated as high quality were eventually joined by a partner, while only 17% of inventions with low quality were joined by a partner.

To examine selection on the demand for financing and the effect of external financing we note that the model implies that the probability to form a partnership to obtain financing increases with project quality, that the marginal investment return should drop once a partner provides financing (indicating liquidity constraints) and that the partnership coefficient should drop once controlling for the external investment. All predictions are supported in empirical analysis. Nevertheless, business partners do not appear to be the major source of external financing since the partnership effect was little reduced when introducing the external investment. Data also show that invention quality is lower when partners provide both ability and financing than when they only provide ability. This result suggests that the proportion of inventors with low assets may be large. It implies that selection on demand for financing may be less since the demand for financing may be primarily from inventors with lower quality inventions.

Accounting for selection, commercialization investment, external financing, and labor hours in Tobit analysis of commercialization revenues the remaining effect of partnership formation must be due to value added or additional heterogeneity. We try to isolate the effect of value added from additional heterogeneity in two ways and find that it represents an increase in the probability of commercialization between 0.06 and 0.09 in both a propensity-score-weighted specification, and in an unobserved-heterogeneity specification. These are economically meaningful results as the probability of commercialization for a solo-entrepreneur is 0.06. The estimated effect of value added on revenues is also large, representing approximately either a 29% or a 38% increase in expected revenues for commercialized inventions, depending on whether we use the propensity-score-weighted or the unobserved-heterogeneity specification. While conditioning on a range of observables as well unobservables, these estimates must still be interpreted as a treatment-on-the-treated effect, that is, the average effect of partners' human and social capital on project revenues for those partners selecting to join inventors. The reason is that we do not know the qualities of the potential partners that did not join the inventors. The estimated value added of partnerships is therefore still, potentially, confounded by unobserved partner characteristics.

Our paper relates to the growing work in finance which tries to estimate the value added of venture capital to entrepreneurs. This effect has been hard to isolate because VCs select on project quality, they probably release credit constraints, and may also provide various forms of value added. The three effects appear simultaneously when projects are financed by VCs. In a recent paper Kerr, Lerner, and Schoar (2010) compare the impact of obtaining and not obtaining informal venture capital for entrepreneurs selecting to apply to two angel financing networks who are just above and below a funding cut-off, thereby eliminating much of explanations based on selection on unobservables. The authors estimate the joint effects of these networks releasing liquidity constraints and providing value added, conditional on entrepreneurs applying to these networks. We take a different approach than Kerr et al., in that we try to separately estimate both the selection and added value effects, and we also try to disentangle the effect of releasing liquidity constraints from value added.

Our setting is admittedly unique. We likely examine a domain where good business partners' human and social capital may be considerably more useful than in regular start-ups such as the mom-and-pop corner store. In this respect our sample is probably similar to that in Kerr's et al. study. At the same time our sample does not contain many projects that receive VC funding and so bargaining issues related to follow-on VC financing are probably unlikely.[26] Nevertheless, our model and empirical methodology is with ease portable to other related domains of investigation and extendable to include analysis of bargaining. Our data further exhibited some limitations such as not linking the type of external investors with the amounts they provide, not counting the number of partners, not collecting contractual information (we doubt there exist much), and not including the characteristics of realized as well as potential partners. These limitations provide opportunities for future research.

The policy implications that one may draw from these estimations must be very tentative given the first-of-a-kind nature of this work. Nevertheless, if the results hold up in future work, it would suggest that for inventive projects, a major policy leverage to increase commercialization rates and revenues is to lubricate the market for finding skilled partners. Furthermore, the analysis echoes the sentiments by angel investors that they have a tough time finding sufficient investment

[26] The fraction which received VC financing was 0.8%, too small to be analyzeable in our study.

opportunities (Mason, 2009). In this study the few projects with high initial quality had twice the participation rate by business partners than those with mediocre quality.

Finally, our work contributes to the literature on entrepreneurial choice. Lazear (2005) develop a theory of entrepreneurs as jacks-of-all-trades where he assumes that the entrepreneur must perform all tasks. The model we propose differs from Lazear's in that we allow individuals with insufficient skills to form partnerships to obtain the required skills rather than having to invest in own skill development. Our model also addresses project financing on which Lazear is silent.

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Appendix A: Inventor's maximization problem

Let $V(Q,Z,A)$ define the value of an invention of quality Q with a potential partner with ability A evaluated at the profit maximizing capital investment as

$$V(Q,Z,A) = \max\{V^P(Q,Z,A), V^S(Q,Z,A)\}$$

where

$$\begin{aligned} V^P(Q,Z,A) &= A(\beta))QK^{*\alpha} + r(Z-K^*) - \tau \\ V^S(Q,Z,A) &= QK^{*\alpha} + r(Z-K^*) \end{aligned}$$

where $\alpha \in (0,1)$, S and P refer to solo-entrepreneurship and partnership, K^* is the commercialization investment that maximizes the value of an invention. The capital investment that maximizes the inventor's profits from commercializing the invention on her own is

$$K^{S*} = \begin{Bmatrix} \left(\frac{\alpha Q}{r}\right)^{1/(1-\alpha)} & \text{if} \quad Q \leq \frac{r}{\alpha}(\lambda Z)^{1-\alpha} \\ \lambda Z & \text{if} \quad Q > \frac{r}{\alpha}(\lambda Z)^{1-\alpha} \end{Bmatrix}$$

which may be constrained by the inventor's assets when the invention quality is sufficiently high $Q > \frac{r}{\alpha}(\lambda Z)^{1-\alpha}$. The commercialization investment that maximizes the partnership's profits from commercializing the invention is

$$K^{P*} = \left(\frac{\alpha A(\beta)Q}{r}\right)^{1/(1-\alpha)}$$

Evaluating the value of the venture at the commercialization investment that maximizes profits, we obtain that the difference between the value of partnership (V^P) and the value of solo-entrepreneurship (V^S) is:

$$V^P - V^S = \begin{Bmatrix} [Q\left(\frac{\alpha Q}{r}\right)^{\alpha/(1-\alpha)} - r\left(\frac{\alpha Q}{r}\right)^{1/(1-\alpha)}][A^{1/(1-\alpha)} - 1] - \tau & \text{if} \quad Q \leq \frac{r}{\alpha A}(\lambda Z)^{(1-\alpha)} \\ \\ [Q\left(\frac{\alpha Q}{r}\right)^{\alpha/(1-\alpha)} - r\left(\frac{\alpha Q}{r}\right)^{1/(1-\alpha)}][A^{1/(1-\alpha)} - 1] - \tau + & \text{otherwise} \\ [Q\left(\frac{\alpha Q}{r}\right)^{\alpha/(1-\alpha)} - r\left(\frac{\alpha Q}{r}\right)^{1/(1-\alpha)} - Q(\lambda Z)^{\alpha/(1-\alpha)} + r(\lambda Z)^{1/(1-\alpha)}] & \end{Bmatrix}$$

An inventor and partner are indifferent between forming and not forming a partnership when $V^P - V^S = 0$. The top equation equals the difference in profits for a non-capital-constrained project with and without a partner. The first bracketed term of that equation is necessarily positive and increasing with Q. The second bracket is also positive and its magnitude depends on the partner's ability.

The second equation shows the difference in profits between partnership and solo-entrepreneurship for those inventions where an inventor is liquidity constrained. As in the top equation, the first two bracketed terms together represents the value added of the partner's ability, which are increasing in Q. The bottom term is the difference between the profits of a liquidity constrained entrepreneur which received financing from a partner and the profits for the same entrepreneur had he not received external financing. This difference is the contribution of a business partnership exclusively formed to increase the capital investment level from the constrained investment level, λZ, to the unconstrained level, $\frac{\alpha Q}{r}$. This term is therefore positive.

Appendix B: Proofs.

Proposition 1. There exist two cut-off rules, $\widehat{Q}^P(Z, A(\beta))$ and $\widehat{Q}^C(Z, A(\beta))$, that describes three potential choices that an inventor (Z, Q) that meets a potential partner with ability $A(\beta)$ can make: no partnership; partnership with financing; and partnership with no financing.

Proof.

We start by showing that there exist a level of Q such that for a fixed Z an inventor is liquidity constrained. Consider two cases: the inventor meets a partner, or she does not. If the inventor does not meet a partner, the constrained investment level is $K^* = \lambda Z$ for $Q > \frac{r}{\alpha}(\lambda Z)^{1-\alpha} = \widehat{Q}^C(Z, p)$. If the inventor meets a partner, we have $K^* = \lambda Z$ for $Q > \frac{r}{\alpha A(\beta)}(\lambda Z)^{1-\alpha} = \widehat{Q}^C(Z, A(\beta))$, where $A(\beta)$ is the partner's ability.

The second cutoff rule $\widehat{Q}^P(Z, A(\beta))$ is the level of invention quality that makes an inventor indifferent between forming a partnership and commercializing the invention solo. Let $V(Q, Z, A) = \max\{V^P(Q, Z, A), V^S(Q, Z, A)\}$ be the value of an invention. $\widehat{Q}^P(Z, A(\beta))$ is the invention quality such that $V^P(\widehat{Q}^P, Z, A(\beta)) = V^S(\widehat{Q}^P, Z, A(\beta))$. There exists a unique cutoff $\widehat{Q}^P(Z, A(\beta))$. For that to follow, it must be the case that $\widetilde{V}(Q) = V^P(Q, Z, p) - V^S(Q, Z, p)$ is strictly increasing with Q and that the value of $\widetilde{V}(Q)$ is positive for some Q (e.g., a Q sufficiently high) and negative for another Q (e.g., $Q = 0$). We will then focus our analysis on showing that $\widetilde{V}(Q)$ is increasing in Q. Let us first consider a Q such that the inventor is liquidity constrained, i.e., $K = \lambda Z$. Then, as Q increases, the value of V^P increases at a faster pace than V^S. Next consider the inventor not liquidity constrained. Here V^P increases at a faster pace than V^S with Q because a marginal change in Q in a partnership is amplified through the partner's ability $A(\beta)$. This is because $A(\beta)$ and Q enters multiplicatively in the revenue of an innovation. Therefore, we can conclude that, for a fixed Z and $A(\beta)$, there exist an invention quality level $\widehat{Q}^P(Z, A(\beta))$ that makes an inventor *indifferent between forming a partnership or working solo.*

Proposition 2. For a fixed wealth Z, the cutoff rule $\widehat{Q}^P(Z, A(\beta))$ is decreasing with the partner's ability $A(\beta)$. Therefore, the probability of forming a partnership increases with the quality of the invention Q.

Proof: We would like to show that the liquidity cutoff $\widehat{Q}^C(Z, A(\beta))$ *and the partnership cutoff* $\widehat{Q}^P(Z, A(\beta))$ *are decreasing functions with the partner's ability* $A(\beta)$. *That* $\widehat{Q}^C(Z, A(\beta))$ *is decreasing with* $A(\beta)$ *for a fixed Z is straightforward because* $\widehat{Q}^C(Z, A(\beta)) = \frac{r}{\alpha A(\beta)}(\lambda Z)^{1-\alpha}$. *Showing that* $\widehat{Q}^P(Z, A(\beta))$ *decreases with* $A(\beta)$ *is somewhat more involved. For a fixed* Q, *the higher* $A(\beta)$ *is, the higher is the the capital investment, and so is the value of partnership* V^P. *The value of solo-entrepreneurship* V^S *does not change with* $A(\beta)$, *so the difference between partnership and entrepreneurship increases with* $A(\beta)$. *Now we have to show that the higher* Q *is, the lower is the different between* V^P *and* V^S. *For a fixed* $A(\beta)$, *the lower* Q *is, the lower is the capital investment and so is the value of partnership and the value of solo-entrepreneurship. However, because* $A(\beta)$*and* Q *enter multiplicatively in the revenue function, the value of partnership will drop more than the value of solo-entrepreneurship. Therefore, we conclude that the higher is the partner's ability* $A(\beta)$, *the lower is the cutoff* $\widehat{Q}^P(Z, A(\beta))$.

Proposition 3. Inventors who are liquidity constrained are more likely than unconstrained inventors to form partnerships.

Proof: To prove this result we must show that for a fixed inventor's wealth Z, *the probability to form a partnership is higher for an invention with quality* $Q > \widehat{Q}^C(Z, A(\beta))$ *than for the rest of the inventions* $Q \leq \widehat{Q}^C(Z, A(\beta))$. *The probability to form a partnership is the probability to meet a partner with ability* $A(\beta)$ *such that* $Q > \widehat{Q}^P(Z, A(\beta))$. *Let us start with inventions where an inventor is not liquidity constrained, i.e., the quality level is such that* $Q \leq \widehat{Q}^C(Z, A(\beta))$. *Here the benefit of partnership is exclusively given by the partner's ability* $A(\beta)$ *and partnerships will only be formed for inventions with invention quality above* $\widehat{Q}^P(Z, p)$ *(see proposition 2). This implies that when* $Q \leq \widehat{Q}^C(Z, A(\beta))$ *the probability of partnership will tend to be low. Alternatively, if an inventor is liquidity constrained (i.e.,* $Q > \widehat{Q}^C(Z, A(\beta))$*), the benefit to form a partnership is due to both the partner's ability* $A(\beta)$ *as well as the increase in the level of capital investment from the constrained level* λZ *to the unconstrained* $K^* = \left(\frac{\alpha A(\beta) Q}{r}\right)^{1/(1-\alpha)}$. *The two effects together are associated with a lower cutoff to form a partnership* $\widehat{Q}^P(Z, A(\beta))$ *than for inventions held by inventors that were not liquidity constrained, i.e.,* $Q \leq \widehat{Q}^C(Z, A(\beta))$. *Therefore, the probability to form a partnership is higher when the inventor is liquidity constrained than for the rest of inventions.*

Proposition 4. Conditional on a partnership being formed, the average ability of a partner is strictly higher than the ability of the average potential partner.

Proof: Recall that $A(\beta)$ is the realization of a stochastic random variable that determines the partner's ability. Before meeting a partner, the ability of a potential partner is $E[A(\beta)]$. For a fixed invention quality Q and inventor's wealth Z, the probability of partnership is the probability a partner $A(\beta)$ meets a inventor with $Q > \widehat{Q}^P(Z, A(\beta))$. Since the function $\widehat{Q}^P(Z, A(\beta))$ is strictly monotone with $A(\beta)$, for a fixed invention quality Q, we can define the probability of partnership Pr($A(\beta) > \widehat{Q}^{P[-1]}(Z, Q)$), where $\widehat{Q}^{P[-1]}$ is the inverse function of $\widehat{Q}^P$. We want to show that conditional on a partnership being formed, the ability of the average partner is higher than the expected ability of a partner, i.e., $E[A(\beta)|A(\beta) \geq \widehat{Q}^{P[-1]}(Z, Q)]] > E[A(\beta)]$. This inequality holds for all Q in a partnership because $A(\beta) \geq 1$. Therefore, the ability of the average partner that formed a partnership is higher than the average potential partner.

Proposition 5. For a fixed ability A, (a) the cutoff rule $\widehat{Q}^C(Z, A)$ is increasing with the inventor's assets Z; and (b) the cutoff rule $\widehat{Q}^P(Z, A)$ is increasing with the inventor's assets Z up to a level of inventor's assets where $\widehat{Q}^P(Z, A)$ is independent of Z.

Proof: First, we show that cutoff rule $\widehat{Q}^C(Z, A)$ is increasing with the inventor's assets Z. Let us consider a level of invention quality Q such that for a fixed Z an inventor is liquidity constrained. There are two cases to analyze. (1) If the inventor does not meet a partner, the constrained investment level is $K^* = \lambda Z$ for $Q > \frac{r}{\alpha}(\lambda Z)^{1-\alpha} = \widehat{Q}^C(Z, A)$. It is easy to see that the function $\widehat{Q}^C(Z, A)$ is increasing in Z because $\alpha \in (0, 1)$. (2) If the inventor meets a partner, we have $K^* = \lambda Z$ for $Q > \frac{r}{\alpha A}(\lambda Z)^{1-\alpha} = \widehat{Q}^C(Z, A)$. Again, it is easy to see that the function $\widehat{Q}^C(Z, A)$ is increasing in Z because $\alpha \in (0, 1)$. Second, we show that $\widehat{Q}^P(Z, A)$ is increasing with the inventor's assets Z up to a level of inventor's assets where $\widehat{Q}^P(Z, A)$ is independent of Z. Let us consider a sufficiently high level of invention quality Q and partner ability A such that a partnership can be profitable. Note that for a given Q and A, there exits a level of inventor's assets $\overline{Z}(Q, A)$ above which the inventor is not liquidity constrained. Above this level of inventor assets, the cutoff rule $\widehat{Q}^P(Z, A)$ will be independent of Z because the partner does not provide value added through the channel of relaxing liquidity constraints. Below the level of assets $\overline{Z}(Q, A)$, the inventor is liquidity constrained and thus the partner provides additional value added through relaxing the liquidity constraint. Note that the higher the assets of the inventor, the lower the potential benefits of partnership and thus the higher is the cutoff $\widehat{Q}^P(Z, A)$.