Avoiding capability traps through contingent contracts: Cash and knowhow in startups

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Abstract
Startup firms must cooperate with the right investor who can meet their needs for cash and knowhow to navigate highly uncertain business prospects. The authors offer insights for managing this issue by examining the terms of a contingent contract for the ownership sharing and cash investment in a two-stage model.

Keywords: Angel financing, Capability trap, Contingent contract.

Introduction
Innovative startup firms are not merely focused on raising money. They must also find knowhow to help them understand and overcome highly uncertain business prospects (Resnick 2010). This creates a dilemma between selecting the investor with the highest bid instead of selecting the one with the highest knowhow (Smith 1998, de Bettignies and Brander 2007). For instance, the founder of Slide, a Web 2.0 company based in San Francisco, California, stated in an interview his regrets for not having a person on board who could tell him when to stop and change direction in his (now defunct) venture (Miller 2011). Startups with little or no track record typically lack resources in attracting costly experts to take a seat on their board and to provide knowhow (Bhidé 2000). A way out is to cooperate with investors who can meet their needs for both cash and knowhow in order to increase the prospects for revenue growth and profitability.

Contracting for knowhow is not a straightforward process. Entrepreneurs and their investors cannot fully know each other's capabilities. Market response to upcoming product offerings is unknown while such contracts are being formalized, and so can be the type and level of knowhow needed. Dependence on the knowhow provided by the investor can create a 'capability trap' for the entrepreneur. A capability trap in this context is defined as a situation where the entrepreneur is unable to secure second stage funding because of insufficient access to relevant knowhow. To address this issue, we investigate contingent contracts featuring cash and knowhow during the development of new business ventures. Contingent contracts are a special type of two stage arrangements between an investor and an entrepreneur, where the end of the first stage is characterized by the entrepreneur meeting a milestone, such as completion or launch of a product.

We ask: *what is the nature of an entrepreneur's payoff-maximizing contract for cash and knowhow subject to the participation of the investor*? *And, how does such a contract set up a capability trap*? The central tradeoff underlying this contract design is based on whether the promised cash and knowhow serve as substitutes or complements. We explore this tradeoff by developing a model in which an entrepreneur, who wishes to maximize his/her payoff, agrees on a two-stage contingent contract with an investor who can provide cash and knowhow for each stage. We recognize the need for different types of knowhow at either stage, and the investor's *ex-ante* level of knowhow is characterized through a probability distribution function, because extrinsic factors (e.g., market response to product placement) create uncertainty. Receiving cash and knowhow at the second stage is contingent on both the entrepreneur and the investor generating enough value for the new business venture at the end of the first stage. Furthermore, the split of cash investment allows the investor to participate while postponing cash transfer and hedge the risk associated with insufficient venture value created by the end of the first stage of the contract.

Theory Base

We review the debate around cash versus knowhow decisions by drawing upon the streams of literature on knowledge-based theory, contingent contracts, and business angel financing. The resource-based view (RBV) of the firm argues for the role of resources as the foundation of firm strategy. A stream of RBV-based literature has advocated for a more dynamic examination of resources in which the firm has the ability to reconfigure its resource base (Eisenhardt and Martin 2000). Dynamic RBV focuses on knowledge as a resource to allow for the development and deployment of dynamic capabilities (Grant 1996) and to pursue technological innovations effectively (Arthurs and Busenitz 2006). The lack of relevant resources, such as organizational or marketplace knowhow, has been shown to create capability traps in established firms. These traps impede the ability to address critical business needs such as the implementation of innovation and process improvement programs.

Given the focus on innovation, knowledge has become a central issue in this literature, particularly in entrepreneurial settings. Knowledge-based theories explain how some firms are better at value creation (Grant 1996) and how firm performance or survival can be enhanced (Wiklund and Shepherd 2003) with knowledge-based resources. Moreover, various types of knowledge are essential for the entrepreneur over time. An investor's ability to provide relevant knowhow (e.g., based either on R&D or market knowledge) for different stages of the venture is a key concern for the entrepreneur. However, the applicability of various types and stages of knowhow, and ascribing valuation to such knowhow, can be ambiguous. This ambiguity creates divergent perspectives and engenders a debate on whether cash and knowhow can be substitutes or complements.

To address the investor's fit for the venture, we examine the terms of a contract contingent on the investor's total cash investment and knowhow for each of early development and growth stages. Fairchild (2011) analyzes the effects of economic and behavioral characteristics on the entrepreneur's choice of financier. Casamatta (2010) surveys what contractual tools can help venture capitalists (VCs) to make relevant decisions and enhance firm valuation, including convertible bonds (Casamatta 2003) and sequential investment (Repullo and Suarez 2004). In these studies, the VC controls the entrepreneurs' actions by monitoring and advising them. We contribute to the literature on financial contracting for startups by studying the cash-knowhow debate with a contingent contract, and consider investment hedging or examine the value of deferred investment and capability traps created by such contingencies that are explored herein.

Research Framework

Consider an entrepreneur (EN) in the process of introducing an innovation for commercialization. The creation of the corresponding new business venture spans over two stages—development (stage 1) and growth (stage 2)—and requires a total amount of cash investment, denoted by k, afforded by an investor (IN). This total investment can be split between the two stages: k_1 (≥ 0) and k_2 (≥ 0) with $k_1 + k_2 = k$. Our model focuses on *contingent financing*, where IN agrees to pay the first portion k_1 at stage 1 and, contingent on the realized venture value, decides whether or not to invest the remaining k_2 ($= k - k_1$) at stage 2. We explore this type of financing because information on venture value can be revealed for stage 2 by observing the EN-IN interaction during stage 1. EN and IN sign a long-term contract at the beginning of stage 1 (Repullo and Suarez 2004) that establishes the terms for venture-value sharing based on EN's ownership share, $s \in [0,1]$, and the distribution of total cash infusion, k_1 and k_2. EN and IN are risk-neutral and the risk-free interest rate is zero (e.g., Casamatta 2003).

In addition to cash infusion, knowhow can augment venture valuation (e.g., Wiklund and Shepherd 2003). Specifically, we consider EN's experience in other business startup, denoted by p (> 0), which is observed by EN and IN. We use p to proxy EN's contribution to the venture's value on the basis that, since EN and IN are engaged in a venture with contractually agreed upon payoff sharing, EN is expected to allocate maximum effort throughout the evolution of the venture and that effort correlates positively with EN's experience with similar endeavors. Venture valuation depends on the (nonnegative) stochastic levels L_1 and L_2 of knowhow delivered by IN during stage 1 and stage 2, respectively.

The risky nature of starting up increases the possible reliance on knowhow. Since the impact of IN's knowhow depends on the risk associated with the prospects of the venture, IN will try to measure various sources of risk in stage 1 and 2. Although some risks can be better controlled than others, the more risk that IN foresees, the less effective is his/her knowhow likely to be. In our model L_1 thus represents an effective level of knowhow for technological development, while L_2 represents an effective level of knowhow for market growth. These knowhow levels are not known a priori to either EN or IN, due to randomness associated with the venture, and are therefore represented by two uniformly distributed random variables on $[0,\mu]$ and $[0,\nu]$. The nonnegative parameters μ and ν are upper bounds on IN's knowhow for stage 1 and stage 2, respectively. For the multiplicative functional form we use to model venture valuation (described next), a bounded probability distribution ensures that, when the upper bound is below 1, the EN-IN interaction results in decreasing valuation (on the corresponding stage) regardless of the potential realization of the knowhow delivered by IN

We use a Cobb-Douglas-type functional form to model the value of the venture. Formally, $V(p, L_1, L_2) = pL_1^a L_2^b$, where the impact of IN's knowhow is scaled by his/her (nonnegative) elasticity parameters a (for stage 1) and b (for stage 2). The multiplicative interaction between EN's experience p and IN's levels of knowhow L_1 and L_2 captures the dependence of the venture's value on each party's contribution. Since L_1 and L_2 are uncertain, an initial long-term contract between EN and IN establishes the terms for the transfer of k_1 and k_2 contingent on L_1. With this contract setting, EN controls his/her risk exposure by managing the tradeoff between IN's *ex-post* continuation and *ex-ante* participation relative to the realization of L_1, while maximizing his/her payoff.

The timeline of events for our two-stage model is as follows. At the beginning of stage 1, EN and IN sign a contract on ownership sharing and the investment split for two stages. EN starts receiving knowhow from IN based on his/her technological knowledge (that informs the venture's development) and an initial investment amount ($k_1 \geq 0$) is contributed. At the end of stage 1, the realization L_1 of IN's knowhow on venture development is observed, and consequently the venture's value is realized. If the interaction does not improve that value sufficiently, it is terminated. If it does, EN receives stage 2's investment k_2 and becomes involved with the growth of the venture. At the end of stage 2, the realization L_2 of IN's knowhow based on his/her market knowledge (informing the venture growth) is observed. The final value of the venture is realized.

We use backward induction to determine EN's ownership share s^* and the resulting split of the total investment in k_1^* and k_2^* that maximize EN's expected payoff, that is, EN's share of the venture's valuation. A threshold level of knowhow $\bar{L}_1$ exists in stage 1, above which IN continues to participate in the venture and thus be also involved in stage 2. Formally, $\bar{L}_1 \equiv \left[\frac{[b+1]k_2}{p[1-s]v^b}\right]^{\frac{1}{a}}$. This continuation constraint enables us to formulate EN's payoff-maximization decision problem for stage 1 and complete the backward induction. Formally, we solve for the optimal contract $\{s^*, k_1^*, k_2^*\}$ that

$$\max_{s\in[0,1],k_1>0,k_2\geq 0} \int_{\bar{L}_1}^{\mu} \left[s\, pL_1^a \frac{v^b}{b+1}\right] dF(L_1),$$

subject to $\int_{\bar{L}_1}^{\mu} \left[[1-s]pL_1^a \frac{v^b}{b+1} - k_2\right] dF(L_1) - k_1 \geq R$ and $k_1 + k_2 = k$ (1)

Since IN should be sufficiently enthused to participate, IN's participation constraint above binds at optimality to guarantee a nonnegative reservation payoff R.

Optimal Solution and Testable Prescriptions

Proposition 1 formally characterizes the optimal ownership sharing s^* and investment amounts k_1^* and k_2^*. Our results will demonstrate that our data fall under three scenarios, where the elasticity of IN's knowhow with respect to providing venture value is positive for stage 1, but either positive or not overly negative for stage 2 (i.e., $a > 0$ and $b > -1$). We therefore focus herein on this scenario and an additional part to this proposition (where $-1 < a < 0$ and $b > -1$), along with all technical proofs, is available from the authors.

Proposition 1. For $a > 0$ and $b > -1$, let $B_1 \equiv \frac{p\mu^a v^b}{[a+1]^2[b+1]} - R$ and $B_3 \equiv \frac{p\mu^a v^b}{[b+1]} - R$.

a) If $0 < k \leq B_1$, then $s^* = 1 - \frac{[a+1][b+1][k+R]}{p\mu^a v^b}$ and $k_1^* = k$ $(k_2^* = 0)$. (2a)

b) If $B_1 < k \leq B_3$, then $s^* = 1 - \sqrt{\frac{[b+1][k+R]}{p\mu^a v^b}}$ and $k_1^* = k - k_2^*$ (2b)

$$\text{with} \quad k_2^* = \left\{\frac{\mu[k+R]}{a}\left[\sqrt{\frac{[k+R]pv^b}{[b+1]\mu^a}}\right]^{\frac{1}{a}}\left[[a+1] - \sqrt{\frac{p\mu^a v^b}{[b+1][k+R]}}\right]\right\}^{\frac{a}{a+1}}. \quad (2c)$$

c) If $k > B_3$, then no investment should be made.

Proposition 1a suggests that no investment be made in stage 2 if the required total investment is sufficiently small. Yet, IN can participate in stage 1 of the contract and, since $k_2^* = 0$, EN shifts the investment risk to IN by collecting all the cash in stage 1 (i.e., $k_1 = k$). To induce IN's participation in stage 1, EN agrees on an ownership share that can deliver IN's reservation payoff R. However, when the required total investment is moderately high, it should be split between the two stages, as portrayed in Proposition 1b. IN then hedges against the investment risk by making a partial investment k_1^* ($< k$) in stage 1, hence keeping the remaining k_2^* above zero. Finally, Proposition 1c suggests that no investment be made at either stage whenever the required total investment is substantial enough. In this case, even offering the option to postpone all cash investment such that $k_2^* = k$ is insufficient for IN's participation. To further characterize the optimal ownership sharing and allied capability trap, we also perform sensitivity analysis on s^* and k_2^*, as well as on the knowhow threshold. This threshold is put in its optimal and normalized form, $\bar{L}_1^*/\mu$. Corollary 1 summarizes this analysis.

Corollary 1. For *a* > 0 and *b* > –1, the relationships between

a) EN's optimal ownership shares s^* and key model parameters are

	μ	ν	p	k
$b > 0$	+	+	+	–
$-1 < b < 0$	+	–	+	–

b) stage 1 normalized knowhow threshold $\bar{L}_1^*/\mu$ and those parameters are

	μ	ν	p	k
$b > 0$	–	–	–	+
$-1 < b < 0$	–	+	–	+

c) the optimal deferred investment k_2^* and those parameters is the same as (b).

We therefore obtain four Testable Prescriptions from Corollary 1a: EN's ownership share s^* *increases* with an increase in either **1.** the upper bound μ on IN's knowhow for the development stage; **2.** the upper bound ν on IN's knowhow for the growth stage; or **3.** EN's experience *p*. However, that ownership share *decreases* with an increase in **4.** the total amount of investment *k*. Prior to empirically investigating these four prescriptions, we next discuss the implications from Corollary 1b-c in the context of capability traps.

Capability Trap and Risk Deterrence

Proposition 1b show the EN receives k_2^* and thus IN participates in stage 2, only when the threshold level of knowhow $\bar{L}_1$ is reached. This creates a range of values for the total cash investment *k*, namely $B_1 \leq k \leq B_3$, where EN faces a capability trap (i.e., where IN does not participate in stage 2 by not providing k_2^* to continue the investment). When there is no possibility of contingent financing (i.e., $k_2 = 0$), the largest amount of cash that EN can receive is $B_2 = \frac{p\mu^a\nu^b}{[a+1][b+1]} - R$. Contingent financing, however, enables the risk to be shared between the two parties through partially deferring the investment amount. In this case, IN releases stage 2 investment k_2 after observing the state of the business venture at the end of stage 1. Due to this option value of the contract, IN can release larger amounts of total cash *k* that can go up to B_3. That is, the increase in the maximum feasible total investment size due to contingent financing is given by $B_3 - B_2 = \frac{p\mu^a\nu^b}{[b+1]}\left\{\frac{a}{a+1}\right\}$, (which also identifies B_1 in Proposition 1).

We further describe the capability trap by also considering the curve of the (normalized) knowhow threshold $\bar{L}_1^*/\mu$, computed for appropriate values of k_2^* and s^*, when k varies between B_1 and B_3. We label this threshold the *capability trap risk* or *CTR*. This is a risk measure because L_1/μ is a random variable uniformly distributed between 0 and 1, and thus *CTR*(*k*) ($\equiv \bar{L}_1^*(k)/\mu$) is the probability that EN will face a capability trap when $B_1 \leq k \leq B_3$. *CTR* rises monotonically on [B_1, B_3], as stated in Corollary 1b. In other words, ventures that require a larger investment face a larger *CTR*.

Noticeably, a larger total cash investment *k* not only increases the *CTR*, but it also increases the optimal deferred investment k_2^* in stage 2, as stated in Corollary 1c. To illustrate the impact of the *CTR* on the contingent contract and, in particular, on the deferred investment, we adjust k_2^* with respect to the level of *CTR* exposure. Since the continuation to stage 2 is dependent on overcoming *CTR*, an adjustment can ensure that the expected value of the deferred investment is appropriately computed for the relevant *CTR*. In other words, with the *CTR* adjustment, the deferred investment is assigned to a lower value, that is, $k_{2CTRA}(k) \equiv \left[1 - \bar{L}_1^{\,*}(k)/\mu\right] \times k_2^*(k)$ for $B_1 \leq k \leq B_3$ (this is equivalent to the calculation of an expected value since the deferred investment equals 0 with probability $\bar{L}_1^{\,*}(k)/\mu$). We term this cash construct the *CTR-adjusted deferred investment*. We also define $k_{2CTRA}^* = \max_{B_1 < k < B_3} k_{2CTRA}(k)$. k_{2CTRA}^* characterizes the value of the largest expected deferred investment available to EN within our dataset.

Methods

We draw upon angel investment data gathered by the Kauffman Foundation and the Angel Capital Education Foundation through the Angel Investor Performance Project (AIPP). The AIPP dataset provides angel investments in early-stage firms throughout nine different states in the U.S. between 1990 and 2007 (for detailed information on this dataset see Wiltbank and Boeker 2007). It reports the amount of cash the angels originally invested in each venture, plus any follow-on investment(s), the years in which they made those investments, the year and type of exit, and the amount of cash they earned back from the venture during the investment period and at the exit. Wiltbank et al. (2009) offer a description of the data collection process and how concerns regarding the representativeness of the data have been mitigated.

Ownership share. We follow the conventional approach of dilution agreement and approximate ownership based on IN's total investment in the venture and the pre-investment valuation of the venture (Neal 2004). IN's ownership share, 1–*s*, is computed by using IN's total investment, *totalinvested*, divided by the sum of all funds invested in the venture at the time of IN's investment, *initrevs* and *totalinvested*. The pre-investment valuation and total investment were reported by the angels, and since we only included the assessment of investments that had actually exited, the valuation data were prone to be more accurate (conservative) than estimates of ongoing ventures (Grimes 2002).

EN's experience. Prior studies suggest that IN assesses EN's experience with a variety of criteria, but entrepreneurial characteristics are, in general, difficult to objectively rank in order of importance (Landström 1998). We thus develop a proxy for EN's experience based on six assessment measures ($j \in [1,6]$) from the AIPP dataset. In the dataset, an IN examined EN's venture i prior to funding and assigned a binary variable $p_{ij} = 1$ if IN identified any corresponding assessment measure *j*, with $p_{ij} = 0$ otherwise. EN's experience is determined by creating a pair-wise index of similarity between each EN and a hypothetical fully experienced EN (Lee 2008).

IN's knowhow. As spillover effects from experiencing stage 1 may reduce the risk in stage 2, the levels of knowhow for stage 1 and for stage 2 may thus be correlated. We address this issue by selecting a number of risk measures, assessed by IN regarding EN's venture, for six dimensions considered in prior work (Wiltbank et al. 2009). We generate two proxies for IN's levels of knowhow L_1 and L_2 based on IN's assessment of venture-related risks. As we argued in the model setup discussion, the effectiveness of IN's level of knowhow is likely to drop with higher risk measures identified by IN (Kaplan and Strömberg 2004, Casamatta 2010). To capture this relationship, we first let x_l and y_l, with $l \in \{1,2,3\}$, denote a binary risk measure for stage 1 and stage 2, respectively, where the reduction in the level of knowhow is associated with the summation of these risk measures. However, since IN's knowhow may overcome part of the risk, we adjust this operationalization. First, we make an adjustment based on the frequency of interaction between IN and EN, where the more frequent the number of interactions between the two parties, the higher the effectiveness of knowhow. Second, we assign the triplet of binary risk measures to the distributions of L_1 and L_2, that is, their respective upper bounds μ and ν. Formally, $\mu_i = INT \times \exp[-(\sum_{l=1}^{3} x_l)]$ and $\nu_i = INT \times \exp[-(\sum_{l=1}^{3} y_l)]$, where *INT* is the frequency of interactions.

Control Variables. Since the industry in which EN operates (*Industry*) and IN's efforts prior to investment (*Due_diligence*) can produce differences in the development of the venture, we consider them as controls. *Due_diligence* is measured by the total number of hours IN spent on EN's market prospects, references, patents and legal position prior to making an investment. *Due_diligence* emphasizes IN's upfront research on the venture (Fried and Hisrich 1994). Moreover, we include *Prior_investors*, which is measured as the number of prior investments, because it serves as a proxy for the upside potential of the venture (Lerner 1994) and may influence IN's assessment.

We present a regression model that uses $1 - s^*$ and its relationship with key model parameters as implied by Proposition 1. For venture i, ownership share $1 - s_i$ is thus a function of the upper bounds on the two levels of IN's knowhow, μ_i and ν_i for stage 1 and stage 2, respectively; the total cash investment k_i; and EN's experience level p_i. By applying logarithmic transformations to Eq. (2a) (or, equivalently, Eq. 2b), and by adding controls and e_i as the error term, we obtain

$$\ln(1 - s_i) = \beta_0 + \beta_1 \ln \mu_i + \beta_2 \ln \nu_i + \beta_3 \ln p_i + \beta_4 \ln k_i + \beta_5 Due\_diligence + \beta_6 Industry + \beta_7 Prior\_investors + e_i. \quad (3)$$

We note that Eq. (2a) may also involve a nonnegative reservation payoff *R* for IN while estimating regression coefficient β_4. Since its inclusion only affects the estimate for the regression coefficient β_4, without a loss of generality we set the value of *R* to 0 in the remaining analysis. Eq. (3) enables us to test Prescriptions 1 to 4 on the sensitivity of EN's s^*. We checked the correlations among the independent and we report no significant correlation between the four independent variables. All variance inflation factors (VIF) and the Durbin-Watson statistics further eliminates concerns about multi-collinearity.

Results

Regression results are reported in Table 1, with the logarithmic transformation of IN's ownership share (1–*s*) as the dependent variable. Among the control variables, *Prior_investors* has a significant negative impact on IN's ownership or, equivalently, a significant positive impact on EN's ownership. However, *Due_diligence* and *Industry* are not significant. We thus report in Model 1 a reference model with a single control variable, while Model 2 adds the four independent variables.

Prescriptions 1, 2 and 4 are supported in Model 2. In other words, EN's ownership share appears to *increase* with an increase in the upper bounds on IN's knowhow for either the development stage or the growth stage, but EN's ownership share appears to *decrease* with an increase in the total amount of investment. In other words, EN can request a higher ownership share when he/she is involved with an IN who can provide higher levels of knowhow for both stage 1 (development) and stage 2 (growth) than with an IN who provides lower levels of knowhow for either stages. Expectedly, IN's participation comes at a cost and EN must give IN a larger piece of the valuation pie when offered larger cash investments. However, Prescription 3 is unsupported in Model 2. In other words, EN's experience does not seem to impact the sharing of ownership based on our sample.

Table 1 – OLS regression results: ln(1–s) as dependent variable

Independent variables	Model 1 Control		Model 2 Main effects	
Intercept	–1.83	***	–9.72	***
$\ln \mu$			–0.42	*
$\ln \nu$			–0.43	**
$\ln p$			–0.24	
$\ln k$			0.69	***
Prior_investors	–2.15	***	–2.31	***
Number of Obs.	33		33	
F statistics	6.91	***	9.31	***
R_a^2	0.35		0.57	

* p<0.1, ** p<0.05, *** p<0.01

We also imputed the two elasticity parameters a and b that characterize the influence of IN's knowhow on creating value for the venture, which enables us to numerically investigate the sensitivity of the capability trap risk *CTR*(k) ($\equiv \bar{L}_1^{\ *}(k)/\mu$, the normalized knowhow threshold) as the total investment k changes. Since our regression specification in Eq. (3) is based on Proposition 1a, our sample is restricted to AIPP investments that exclude stage 2 investment to obtain $-a = \beta_1$ (μ's regression coefficient) and $-b = \beta_2$ (ν's regression coefficient). Subsequently, we apply these imputed values $a = 0.42$ and $b = 0.43$ for numerical work over the entire range of investment.

Capability Trap Risk

We provide a graphical illustration of our findings in Figure 1 to facilitate the interpretation of the *CTR* and to characterize its impact on contingent contracting based on the magnitude of the *CTR*-adjusted deferred investment, $k_{2CTRA} \equiv [1 - CTR(k)] \times k_2^*(k)$. We use key statistics from our AIPP sample, along with the imputed elasticity parameters $a = 0.42$ and $b = 0.43$, to quantify the *CTR* for the relevant range of the total cash investment k, that is, $B_1 \leq k \leq B_3$. The average values for the two upper bounds on knowhow (for IN) and experience (for EN) are, respectively, $\bar{\mu} = 3$, $\bar{\nu} = 3$ and $\bar{p} = 0.5$ for the sample. We use these parameters to construct a base case (with $a = 0.42$, $b = 0.43$ and $R = 0$), while varying the values of total cash investment k over the entire relevant range of sampled investments (in million $). We also draw that curve for when $\mu \in \{1.05, 4.95\}$, $\nu \in \{1.05, 4.95\}$ and $p \in \{0.15, 0.85\}$ to reflect the parametric variation.

The variations in the *CTR* and *CTR*-adjusted deferred investment in our numerical analysis show the monotonic increase in *CTR* as k increases. Table 2 illustrates the economic intuition based on a tradeoff between the trap-risk adjustment $[1 - CTR(k)]$ and the deferred payment $k_2^*(k)$. When EN contracts for a high level of deferred payment due to a large total cash investment k (for $B_1 \leq k \leq B_3$), the trap-risk adjustment goes down. Determining the largest $k_{2CTRA}(k)$, or k_{2CTRA}^*, is managerially relevant because it illustrates the value of the largest expected deferred investment available to EN.

Table 2 also presents the minimum B_1 and maximum B_3 of total available cash through contingent contract. We observe that, for the entire relevant range of contract inputs μ, ν and p,

k^*_{2CTRA} does not occur at the extreme values of the range $B_1 \leq k \leq B_3$. We also verify that k^*_{2CTRA} increases with μ and ν, and that it varies between 0.19 and 0.35; the variation range is similar for these two parameters because their numerical value is roughly the same for our sample. On the other hand, k^*_{2CTRA}, which also increases in EN's experience p, varies between 0.09 and 0.49 owing to variation in p. In other words, in the contracts examined herein, the realizations of contract inputs based on IN's knowhow (i.e., μ and ν) and EN's experience (i.e., p), along with the largest expected deferred investment available to EN (i.e., k^*_{2CTRA}), all influence EN's ability to reduce the capability trap risk.

Table 2 – Characterization of the maximum capability trap risk adjusted differed investment

Control parameters	B_1 = lower bound on available cash with deferred investment	B_3 = upper bound on available cash with deferred investment	Level of cash that gives maximum *CTR*-adjusted deferred investment	k^*_{2CTRA} = Maximum *CTR*-adjusted deferred investment
Base case	**0.44**	**0.89**	**0.53**	**0.29**
μ = 1.05	0.28	0.57	0.34	0.19
μ = 4.95	0.54	1.09	0.65	0.35
ν = 1.05	0.28	0.57	0.34	0.18
ν = 4.95	0.55	1.10	0.65	0.35
p = 0.15	0.13	0.27	0.16	0.09
p = 0.85	0.75	1.51	0.90	0.49

Concluding Remarks

The cash-knowhow debate hinges on the argument that entrepreneurs must carefully consider characteristics of the investors with whom they build a relationship and assign them an appropriate share of the proposed business venture, because the type of investors that can aid early-stage development may differ from the type that can aid in growth events. We have examined the terms of a contingent contract with which the entrepreneur and the investor determine the ownership and investment split that would configure a portfolio of cash and knowledge-based resources, such as knowhow and experience, and ensure the entrepreneur-investor collaboration.

The findings from our analytical development, regression analysis and numerical assessment offer implications for shaping contingent contacts. First, increasing upfront knowhow makes the investor attractive to the entrepreneur. We specify the measures for ownership shares and (relative) stage 2 investment to quantify the optimal contingent contract in Proposition 1.
Second, setting up a contingent contract allows the investor to hedge investment risk. When faced with uncertainty, the investor may reduce the investment risk by, for instance, setting up a contingent contract, conducting due diligence and asking for stricter terms to avoid potential losses. Third, assessing the capability trap risk and options associated with deferred investment can be beneficial to both parties. Analytical (Corollary 1) and numerical findings (Table 2) suggest that splitting the total available investment (k) between two stages by manipulating the investor's level of knowhow (μ and ν) and the entrepreneur's experience (p) brings changes in the amount of capability trap risk. Managers of startups ought to be able to use their *ex-ante* assessments of investors' knowhow for their new business venture, their own experience and total cash infusion to understand and assess the level of capability trap risk and the value they create through the expansion of investment options.

While our model lets us study the fundamentals of the entrepreneur-investor interaction in detail, several assumptions and related extensions are relevant. First, we developed a model that considered two different elasticity parameters in generating value from the investor's knowhow, but mostly focused on a specific case (where we empirically found them to be roughly equal). A deeper investigation of these elasticity parameters could explain the need for different types of knowhow at either stage. Second, while we provided empirical evidence to support our prescriptions, additional analytical and empirical developments could consider different learning curve effects, spillovers or other forms of knowledge generation between the entrepreneur and the investor.

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