

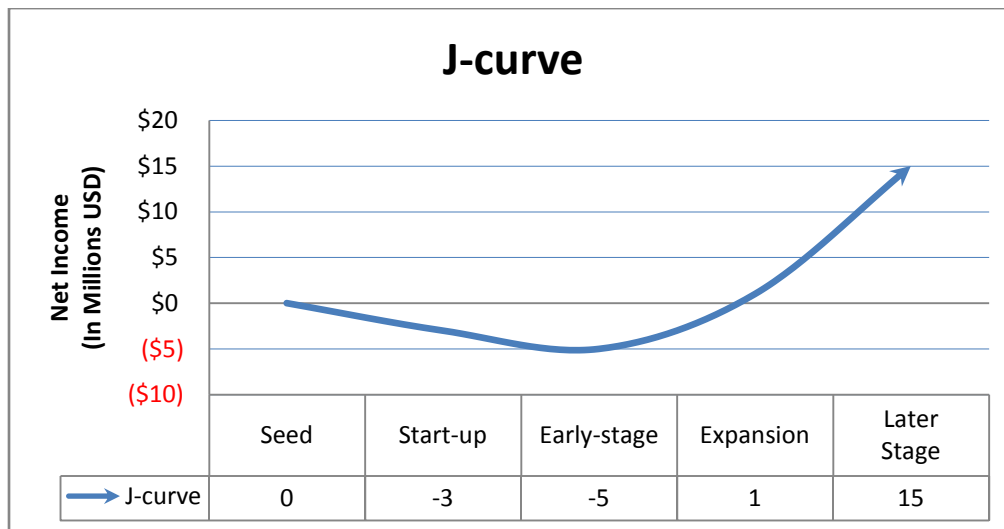
# RESOURCE COMPLEMENTARITIES, TRADE-OFFS, AND UNDERCAPITALIZATION IN TECHNOLOGY-BASED VENTURES: AN EMPIRICAL ANALYSIS

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## EXTENDED EXECUTIVE SUMMARY VERSION

Among technology-based ventures, undercapitalization is frequently identified by practitioners and academics as a central obstacle facing new ventures. For example, Albert Bruno and several colleagues tracked the evolution of 250 technology ventures started in Silicon Valley in the 1960's for 20 years and reported that, based on interviews with founders, challenges associated with "initial undercapitalization" was a central cause of firm failure. Among technology ventures, these capitalization challenges often arise from the use of a commercialization model characterized by high-fixed costs coupled with non-existent revenues during the start-up phase. Over time, once investments into the development and production of the venture's core technology are complete, firms with superior products and services should enjoy high rates of revenue growth. A hypothetical "J-curve" illustrated below charts the generation of net income by a venture successfully utilizing this commercialization model (i.e., initially negative followed by the exponential growth of net income).



To finance the "trough" portion of the *J*-curve (when net income is negative), many ventures rely on the investments of business angels, venture capitalists, and/or corporate investors to resolve these early capitalization challenges to produce future growth. Despite the significant impact of these types of investments on young ventures, acquiring investment capital is no guarantee of success. For example, eToys, founded in 1998, raised through a combination of various sources over \$300 Million (USD) in external investments (i.e., private/VC; IPO; Private Equity). However, these funds proved to be insufficient to sustain operations much beyond the three-year mark, and therefore the venture declared bankruptcy in early 2001.

For us, the eToys example illustrates an important issue in entrepreneurial finance: In most cases, the sufficiency of a venture's capital base is relative to the initial start-up costs derived from the venture's development strategies for determining a venture's survival prospects. It is possible, therefore, for ventures to be *undercapitalized* even when raising millions of dollars in invested capital if the strategies implemented by the firm spend a greater amount of capital than initially raised. This distinction is important because in the academic literature, the absolute (versus the relative) size of the capital base is often utilized to determine the sufficiency of a venture's capital base.

Others, however, argue that some undercapitalization can actually be a positive catalyst for decision making among venture managers since it often induces creative strategies for maximizing the efficient use of scarce resources. In the eToys example, these folks would argue that perhaps eToys possessed too much capital and therefore had less motivation to efficiently invest their capital (In fact, we sometimes hear anecdotal reports of investors deliberately "starving" their portfolio firms during the early-stages, in part, to induce such creative problem-solving efforts).

In light of these competing views, we initiated this study to seek answers to two main questions: 1) What is the relationship between undercapitalization and firm survival among young technology-based ventures? 2) Why are some young ventures better capitalized than others?

## **UNDERCAPITALIZATION AND FIRM SURVIVAL**

Based on an extensive review of the academic and practitioner literatures on undercapitalization, we developed two sets of hypotheses designed to investigate these research questions. The first set of hypotheses examines the exact nature of the relationship between undercapitalization and firm survival; Specifically, whether different threshold points exist in the relationship between the venture's capital base and firm survival (these threshold points are important because they can tell us whether no/some/much undercapitalization matters in shaping a venture's survival prospects). This first set of hypotheses is listed below:

*Hypothesis 1a: There is an inverse relationship between undercapitalization and firm survival among technology-based ventures (the greater a venture's capitalization level, the greater are its chances of survival).*

*Hypothesis 1b: There is a curvilinear relationship between undercapitalization and firm survival among technology-based ventures.*

*Hypothesis 1c: There is a cubic relationship between undercapitalization and firm survival among technology-based ventures.*

Hypothesis 1a tests the idea that more undercapitalization increases a venture's risk of failing. Essentially, confirmation of this relationship would suggest that technology ventures are more likely to survive when they meet their capitalization goals. Hypothesis 1b tests the idea that a single threshold point exists in the relationship between undercapitalization and firm survival; Specifically that ventures are likely to survive when they reach a certain capitalization level even if they have not met all their goals (conversely, ventures falling below this threshold point would face an increased chance of failing). Third, Hypothesis 1c tests the idea that a more

complex relationship exists between undercapitalization and firm survival; Specifically that multiple regions exist in the relationship between undercapitalization and firm survival.

Regarding the potential causes of undercapitalization, we investigated the effects of and interrelationship among the quality of the venture's management team and technological resources on a venture's relative level of capitalization since these tend to be the central factors around which most young ventures organize. The foundation of this research builds on an emerging paradigm that explores the effects of complementarities on firm outcomes (i.e., firm performance; here—capitalization levels). The essences of complementarities or synergies is that two resources (when linked together) are more valuable/effective than a single resource in isolation. So, our preliminary expectation was that a strong management team—when coupled with an equally strong technology—would be best able to meet its capitalization goals; and that increased levels of undercapitalization would occur when ventures possessed weak management teams and technological resources.

The practical reality for most investors, however, is that it is quite difficult to find ventures with equally strong management teams and technologies. As such, most investors recognize that they often have to make trade-offs among these factors (e.g., fund a potentially weaker management team with a possible cure to cancer). When doing so, however, most investors tend to subscribe to Georges Doriot's (widely recognized as the founder of the venture capital industry in the United States) idea that they would rather invest in an "A" management team with a "B" technology, than an "A" technology with "B management team. In other words, these investors tend to tilt towards the management team when making investment decisions. In our study, we attempted to put this explanation to the test. The hypotheses designed to test these relationships are listed below.

*Hypothesis 2a: There is an inverse relationship between the quality of a new venture's managerial resources and undercapitalization among technology-based ventures.*

*Hypothesis 2b: There is an inverse relationship between the quality of a new venture's technological resources and undercapitalization among technology-based ventures.*

*Hypothesis 2c: The joint effect of a new venture's technological and managerial resources reduces undercapitalization among technology-based ventures over and above the individual effect of both resources.*

## **RESEARCH METHODS and DATA**

To test our hypotheses, we utilized a sample of 144 Oklahoma ventures that started with a technology and made strides to move forward with technology commercialization efforts through the development of new ventures. Over the past 10 years, approximately 144 applications were filed for assistance with i2E, an Oklahoma non-profit corporation focused on developing technology-based ventures (i.e., see <http://www.i2e.org> for more information). After eliminating cases where incomplete data made it impossible to reasonably estimate missing variables from other data within the sample, the final sample utilized in this study consisted of 79 firms spanning 39 unique industry sectors (i.e., 6-digit NAICS).

To measure undercapitalization we used four specific variables. First, to measure whether a venture was undercapitalized relative to its growth needs, we divided the total capital raised by the two-year sum of *Cost of Goods Sold* and *Marketing/Advertising* expenditures reported on the *pro forma* Income Statement (Total Capital Raised/(2-year COGS+Marketing & Advertising)). To measure undercapitalization relative to the total capital needs of the venture, we divided the total capital raised by the investment goal of the venture as reported in the business plan (Total Capital Raised/Investment Goal). For financing the operational needs of the venture, we divided the two-year sum of *Net Income* on the *pro forma* Income Statement (Total Capital Raised/2-year Net Income). Finally, to determine the sufficiency of the venture's capital base relative to the total assets needed by the venture, we divided the total capital raised by the two-year sum of the *Total Assets* on the *pro forma* Balance Sheet (Total Capital Raised/2-year Total Assets). We used the two-year summed projections from the various *pro forma* financial statements since a standard tactic in business plan writing is to utilize the first two years to demonstrate the venture's survival needs.

To calculate the venture's survival time, we determined the number of months between the start date of the venture as reported by the data provider and either the time when the venture closed (or was acquired) or the study completion date of December 31, 2007 (which, interestingly enough, is the very month in which the current recession began—more on this later!).

To measure the quality of a venture's management team, we utilized scores from the consulting staff of i2E which basically captures the experience and proven track record of the management team, quality of the board of advisors, among other factors. These measures are developed before the venture attempts to raise capital and have the added advantage of being developed by staff consultants who all have rich prior experience either as an entrepreneur and/or investor. To measure the quality of the technological resources, we also utilized scores from from the i2E consulting staff which captures the relative industry lifecycle characteristics, the technology's platform capabilities, and intellectual property protections, etc.

To control for alternative explanations of the results obtained in this study, we utilized a set of variables including *industry sectors*, *year of start-up*, *commercialization stage*, *the munificence of the environment (which measures the availability of resources for companies operating in various industry spaces)*, *any prior investment raised by the venture*, *other capital raised (i.e., grants/loans)*, *bootstrap finance*, and *bootstrap operational expenses* to partial out these effects.

To test the first set of hypotheses we used an accelerated failure time model (i.e., hierarchical lognormal survival analysis) which calculates the probability a venture will fail at any given point of time based on a set of included variables (i.e., our independent and control variables). This is a similar statistical technique a medical researcher might use to determine the effect of a specific treatment on an individual's survival prospects. To test the second set of hypotheses, we used hierarchical two-limit tobit regression—a specialized statistical technique which accounts for the fact that the dependent variable (e.g., here—undercapitalization) only ranges from 0% to 100%.

## RESULTS

The results of both sets of tests of our hypotheses are listed below. Table 1 reports on the test of the relationship between undercapitalization and firm survival, and Table 2 reports on the test of the relationship of management team and technological resources with undercapitalization.

**TABLE 1**  
**RESULTS OF HIERARCHICAL LOGNORMAL SURVIVAL ANALYSIS**  
**(WITH POLYNOMIAL TERMS)**

Dependent Variable:	Model 1	Model 2	Model 3	Model 4
Venture Survival	Controls	Polynomial	Polynomial	Full Model
<b>Controls:</b>	Parameter	Parameter	Parameter	Parameter
CS4	-1.3043*	-0.3679	-0.2392	0.3064
CS5	-3.5956	-4.0283	-3.2715	-1.9293
Munificence	0.0057	0.0110	0.0118	0.0190*
Salary/Revenue Ratio	4.5491†	5.8408*	6.3093*	7.5923**
Price-Cost Margin	9.2964**	10.0941***	9.9440***	10.2472***
Team Size	0.1095	0.0627	0.0889	0.1888
Other Capital	0.0000	0.0000	0.0000	-0.0000
Previous Investments	0.0000†	0.0000	0.0000	0.0000
TECH	0.0379	0.0578*	0.0611*	0.0719**
MGT	-0.0345	-0.0603*	-0.0567*	-0.0814**
<b>Polynomial Terms:</b>				
Undercap <sup>3</sup>		0.7877**	0.8276***	2.5466**
Undercap <sup>2</sup>			-0.6090	-1.3357*
Undercap				-1.9820*
<b>Model Statistics:</b>				
Log Likelihood	-47.59621	-41.10188	-40.21109	-36.78838
G <sup>2</sup>	27.57935	40.568	42.34958	49.195
Cox & Snell R <sup>2</sup>	.295	.402	.415	.464
Δ Cox & Snell R <sup>2</sup>		.107	.013	.049

N=79. \*\*\* p<.001, \*\* p<.01, \* p<.05, † p<.10

As indicated by Table 1, the parameter estimates for Undercap<sup>3</sup> and Undercap are both statistically significant indicating support these hypotheses. The specific term for Undercap<sup>2</sup> in Model 3 is not significant thereby indicating a lack of support for this hypothesis. We are still working on finalizing a plot of these polynomial terms, but a basic calculation indicates the survival curve inflects down at 19% Undercap and inflects up at 81% Undercap. We would caution readers not to generate any law-like inferences from these data (i.e., achieving 81% of your capitalization goals is a guarantee of success and only achieving 19% of your capitalization goals is a guarantee of failure). We would like to study this specific relationship a bit more and, if possible, replicate our findings with a different set of data.

**TABLE 2**  
**RESULTS OF HIERARCHICAL TWO-LIMIT TOBIT REGRESSION**

Dependent Variable:	Model 1	Model 2	Model 3	Model 4
Undercap	Controls	MGT	TECH	MGT*TECH
	(Normal)	(Normal)	(Normal)	(Normal)

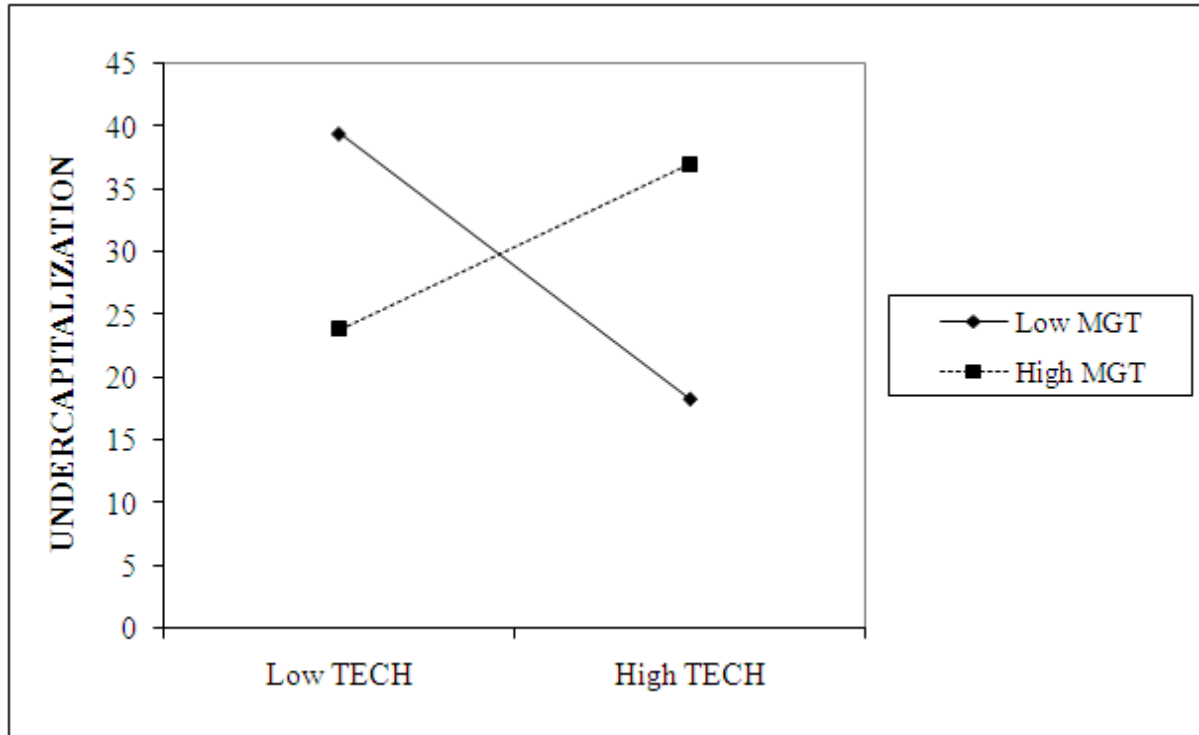
<b>Controls:</b>	Parameter	Parameter	Parameter	Parameter
NAICS 333315	62.9146†	72.3694*	69.3402*	69.1373*
NAICS 334512	53.9903	57.2596†	60.2957†	68.2943*
NAICS 424690	52.7914	58.9388†	69.5462*	78.2600*
NAICS 511210	-23.4581†	-24.4297†	-29.6664*	-35.6266**
NAICS 517210	-29.7975	0.5763	15.8389	57.7852
NAICS 519130	-11.3682	-17.4867†	-18.0060†	-16.4768†
NAICS 541511	-18.3286	-23.2386†	-17.0201	-24.9519†
NAICS 541512	-42.6671*	-46.3199*	-48.7742*	-54.1405**
YR 2006	-8.3006	-12.9790	-14.6148	-13.2518
YR 2005	-33.2407†	-27.6851†	-29.3882†	-24.1324
Env Mun	-0.0880	-0.1057	-0.1451	-0.3445
<b>Direct Effects:</b>				
TECH		-1.7362***	-1.8216***	-1.9661***
MGT			0.7274*	0.8071*
<b>Interactions:</b>				
MGT*TECH				8.5886†
<b>Model Statistics:</b>				
Log Likelihood	-387.4658	-382.1186	-380.5844	-378.772
$G^2$	21.06185	31.75613	34.82469	38.44943
Cox & Snell $R^2$	.234	.334	.360	.389

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N=79. \*\*\* p<.001, \*\* p<.01, \* p<.05, † p<.10.

Table 2 indicates support for the hypothesis predicting a significant joint effect (i.e., complementarity) between the venture's management team and technological resources. To fully illustrate the specific nature of this relationship, we plotted out the interaction in Figure 1 illustrated below.

**FIGURE 1**  
**PLOT OF THE JOINT EFFECT BETWEEN MANAGEMENT TEAM AND TECHNOLOGICAL RESOURCES ON UNDERCAPITALIZATION**



The results of this interaction plot are quite interesting and represent a divergence from conventional wisdom in investments into technology ventures. As expected, the combination of strong management teams with strong technologies proved to be quite successful in meeting the venture's capitalization goals. However, the combination of weaker management teams with weaker technologies yielded an equally high capitalization ratio. The lowest capitalization ratios emerge when investors are making trade-offs between a management team and a technology. Therefore, contrary to conventional wisdom strong management teams do not appear to be able to compensate for a weak technology any more than a strong technology can compensate for a weak management team. We discuss these findings in more detail below.

## **DISCUSSION**

In sum, this study offers two important insights into the capitalization process of early-stage ventures. First, the confirmation of a complex relationship between undercapitalization and firm survival suggests that ventures with moderate levels of undercapitalization can still be successful even though they have not met their capitalization targets (i.e., here we define moderate undercapitalization as capitalization ratios between the two inflection points—19% and 81%). As our results indicate, a venture's probability of surviving does not appear to be

influenced either way by its relative capitalization level when the venture is between these inflection points (i.e., the “survival curve really is flat!). Success, we think, for these companies is more contingent upon the type of strategies implemented by the venture. Specifically, by focusing on reducing operational costs young ventures can work to reduce cash outflows to preserve their capital base. Forgoing management salaries, outsourcing non-“mission critical” development tasks, utilizing a barter system with service providers to gain access to key services (i.e., accounting, etc.), utilizing the services of a virtual CEO/CFO, not hiring a direct sales force too early, etc. are all specific cost reduction strategies firms can implement to reduce their fixed operating expenditures. Given some of the recent challenges in the macro-economic environment, reducing costs to preserve capital is a critical step in helping mitigate challenges with undercapitalization.

The second major finding in this study centers on the joint effect between managerial and technological resources and undercapitalization. As we described above, contrary to conventional wisdom regarding the relative importance of management teams versus technologies, our study indicates that relative weaknesses in either dimension tends to increase a venture’s risk of becoming undercapitalized. Conversely, ventures without trade-offs on either dimension tend to be most successful in reaching their capitalization goals.

Finally, as we noted above, our study end date occurs in exactly the same month when the current recession began. Although the current study does encompass the inflation and collapse of the tech bubble in 1998-2000, we have yet to analyze the effects of the current financial crisis for technology ventures. We are continuing to collect data and are curious to see how the current crisis affects some of our results. Our view right now is that the effects of the current crisis will actually strengthen some of the relationships we found in this initial study.<sup>1</sup>

***Study references available upon request.***

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<sup>1</sup> For example, in recent interactions with an entrepreneur who is starting a biotech company indicated that she and her colleagues have been able to secure some “amazing” deals on facilities and equipment because of suppressed demand in the current economic recession. Although recessions create unique managerial challenges, they also can present unique long-term opportunities for ventures who can take advantage of lower costs for key resources.