Sample Selection and Theory Development: Implications of Firms' Varying Abilities to Appropriately Select New Ventures

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SAMPLE SELECTION AND THEORY 
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I highlight the need to consider sample selection when developing theory. When a sample is the result of a selection process, the process may be (1) generating empirical relationships consistent with a theoretical explanation that plays no causal role or (2) canceling out an empirical relationship actually generated by a causal process associated with a proposed theory. I argue that firms’ varying abilities to appropriately select new ventures and select in or out of samples of such investments can lead to empirical misinterpretation and inappropriate theoretical conclusions.

Whether a theory begins with a logically deduced conjecture (e.g., Popper, 1968), the detailed observation of a phenomenon (e.g., Glaser & Strauss, 1967), or an “interim struggle” such as abstracting and generalizing (Weick, 1995), empirical analyses play a crucial role in shaping the theory. In disciplines where inductive theory building is common, for example, researchers often work backward from unexpected empirical results to modify theory. Even for researchers working in a positivist tradition, empirical regularities have an important influence on the direction of future theory. Empirical evidence consistent with existing theory encourages further, more precise theory to be deduced in the same vein as the original. Empirical evidence contradicting existing theory often provides the motivation for researchers to articulate alternative theories, or at least contingencies to the existing theory.

This paper highlights the need for researchers to consider sample selection when developing theory. When a sample observed by the researcher is the result of a selection process, the process may be (1) generating empirical relationships consistent with a theoretical explanation that, in fact, plays no causal role or (2) canceling out an empirical relationship that is actually generated by a causal process associated with a proposed theory. Sample selection frequently has been discussed by methodologists (e.g., Heckman, 1979) but rarely has been considered by those developing theory in the social sciences. To show how selection issues may affect theory, I develop selection-based propositions regarding the choices made by entrepreneurs or established firms regarding whether to invest in a new venture, using as an illustrative case the large foreign direct investment (FDI) literature and, to a lesser extent, the new product development literature. I show that selection issues may cause empirical findings in these bodies of literature to be misinterpreted in the two ways mentioned above.

To give some insight into the intuition behind my arguments, I provide an unrealistic but hopefully illuminating example. Consider a hypothetical scenario in which firms always completely and correctly evaluate FDI ventures under consideration. Some firms discover that their ventures have a positive net present value; these firms then initiate the ventures (select into the sample). The remaining firms realize their ventures would lose money and, thus, do not initiate their ventures (select out of the sample). Once initiated, venture performance is completely predestined. The naive researcher interested in FDI collects data in some foreign markets and finds only successful ventures. The researcher may conclude that an innate property of FDI is that it is always successful, and he or she may develop a theory about why this is

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the case (e.g., people prefer the products of foreign companies). Other researchers successfully replicate the original findings and conclude that, in fact, the theory has validity. Of course, any causal theory about why FDI is universally successful does not have validity in the simple world of this scenario. FDI's apparent unanimous success arises here only because of appropriate selection into the sample.

I now make this hypothetical example slightly more complex. Consider a scenario with two types of firms. One group can always correctly evaluate ventures under consideration, like those in the previous paragraph. Another group of firms exists at the other extreme, having little ability to evaluate their potential ventures. Further, the second group differs in some way from the group of correct evaluators; the second group may be less experienced, for example. The researcher analyzing a sample of FDI activity (that includes both types of firm) will only observe failures among the second group of firms. As above, managers can do nothing to alter their ventures' destinies after initiation. The researcher may develop a theory about how inexperience leads firms to make mistakes once they have initiated their venture. Such a theory may have validity in reality, of course, but empirical results based on a sample resulting from this scenario do not support this interpretation.

In this example inexperienced firms are more likely to fail only because they initiate many FDI ventures in cases when they should not. In other words, some inexperienced firms inappropriately select into the sample of firms engaging in FDI. In the body of the paper I develop a model that builds on this intuition to contrast the causal and selective effects of firm experience on the likelihood of venture failure and on the size of the resource commitment required to initiate the ventures.

The propositions in this paper apply to the subset of selection processes where (1) the researcher wishes to analyze a performance-type outcome, (2) the choice of selecting into or out of a sample can be viewed as "correct" or "incorrect," and (3) an exogenous characteristic of the actor, such as experience (or, more generally, any capability), influences the actor's likelihood of making the correct choice. In this sense the model goes beyond the insights of standard treatments of sample selection (e.g., Heckman, 1979), which assume that noise in the selection process affects all actors equally. In econometric terms, heteroskedasticity is present in the selection process presented in this paper. While econometricians have begun to develop estimation models for sample selection with heteroskedasticity (e.g., see Vella, 1998: 142), lemmas such as those developed in this paper that contrast causal and selective effects have not been articulated in the methodological literature.

The sample selection issues presented here are distinct from two other important selection issues: nonresponse bias and survivor bias. First, my propositions regarding selection could be considered similar to nonresponse biases discussed extensively in the survey methodology literature (e.g., Armstrong & Overton, 1977) because both result in an important subset of potential data not being available for observation. Like sample selection, nonresponse may be associated with an exogenous variable. A relationship present between that and other variables in only part of a sample may be ignored or exaggerated because of the nonresponse. But, in my selection model, since the firm's ability to select appropriately is altered by an exogenous variable, the selection effect can actually systematically cause the appearance of a relationship between variables where, in fact, there is none when considering the entire population (or any subsample). Nonresponse bias does not cause such effects.

Second, similarities exist between my sample selection–based propositions and survivor bias (e.g., Denrell, 2003; Golder & Tellis, 1993). Survivor bias occurs when researchers or other firms are unable to observe or gain information about failures. Like my propositions, survivor bias may cause an illusory but systematic and replicable relationship between variables. The difference is that survivor bias involves selection on the dependent variable, whereas in the selection processes that I analyze, an independent variable alters firms' abilities to appropriately select in or out of a sample.

I organize the body of the paper as follows. First, after providing a brief review of the literature on selection biases, I present a general model of the evaluation and possible initiation of a venture under consideration by a firm. Four lemmas are derived from this model. Two lemmas present results regarding the probability of venture success. Two others concern the average estimated value of the venture. Second, I
discuss the relationship between new venture success and a firm's experience. The logic of the first two lemmas is used to illustrate how a firm's experience can be related causally and through selection to venture success. This section concludes with a discussion of how implications for theory differ, depending on which process is influenced by experience. Third, I discuss the relationship between a firm's experience and the initial resource commitment for a new venture. Again using the lemmas I derive, I show how causal and selection effects may explain the lack of consistency in empirical results found to date. I conclude with discussions of limitations and extensions of my model and of possible solutions to the sample selection issue that I have highlighted.

THE LITERATURE ON SELECTION MODELS

The basic idea that selection can bias statistical inference about empirical relationships between a variable chosen by an actor and an outcome variable resulting from the actor's choices has been understood in the methodological literature since at least Heckman's (1979) pioneering work. Selection issues in social sciences research can be split into two categories: (1) sample selection—that is, an observation (or at least its dependent variable) is only available to the researcher if the actor "selects" into the sample (Heckman, 1979)—and (2) selection into groups, given observability (e.g., Lieberson, 1985; Shaver, 1998). This latter type of selection is often referred to as the treatment model, based on the analogy that one group has selected to receive a "treatment" while another acts as a control group. This paper builds on the concept of sample selection by introducing the idea that firms' abilities to appropriately select into or out of a sample vary, and firms' characteristics affect their selection abilities. The standard sample selection models assume equal selection abilities among all actors.

The canonical example of sample selection discussed by Heckman (1979) is the model of female labor supply. Heckman realized that any analysis of the female labor force only considers those women who have selected into the labor force "sample," likely because their market wage is greater than their reservation wage (the value they gain by remaining out of the workforce). Another popular example is the case of migrants' wages. Nakosteen and Zimmer (1980) noted that only those individuals for whom migration is beneficial have likely selected into the sample.

In sociological work, Lieberson (1985) noted the pervasiveness of selection issues, emphasizing that most social processes are, in fact, selection processes. He illustrated selection bias using the treatment example of the relationship between parents' choice of private school or public school and the outcome of student test scores. He highlighted the noncausal correlations that result when unobservable characteristics (e.g., the parents' perception of their child's ability) are correlated both with school choice and with test scores. Shaver (1998) called attention to the treatment process that underlies the choice between two alternative entry modes for FDI. He demonstrated the inappropriateness of concluding that the greenfield entry mode is more risky than the acquisition entry mode based on the often replicated empirical relationship that greenfield direct investments are more likely to lead to the outcome of failure. The relationship is, in fact, the result of selection rather than a causal process: companies with subsidiaries that were more likely to fail—regardless of entry mode—happened to typically choose greenfield investments. Hamilton and Nickerson (2003) presented a broad review of managerial phenomena subject to treatment-style selection processes along with empirical solutions.

A MODEL OF VENTURE VALUATION

In this section I present a model of venture valuation. Entrepreneurs, venture capitalists, or established firms (hereafter referred to simply as firms) may evaluate the potential of expansion to a new foreign market. Alternatively, the firms may wish to diversify into a new product market. These ventures may or may not prove successful. Variations of this model highlight causal and selection-based relationships between a firm's experience and likelihood of venture success and between experience and level of initial resource commitment. The selection-based relationships emerge from these broad assumptions of the model: (1) all firms have the same decision rule, but (2) they differ in their ability to apply the decision rule appropriately and (3) our powers of observation are limited to
those who have decided to enter the new market. These assumptions and their implications are specified in more detail below.¹

The Parameters of the Model

A firm decides whether to initiate a new venture based on an initial valuation. The firm generates an imperfect estimate \( v_i \) of the net present value of the venture \( i \). The estimates are costly, so the firm only estimates the value of each venture once. The firm uses the decision rule that if its estimate \( v_i \) is greater than zero (or any constant threshold), it will initiate the new venture. If it estimates a negative \( v_i \), it will not. This decision rule is identical to one that would be based on a positive rate of return. The actual net present value of the firm’s venture is \( R_i \), a draw from a normally distributed random variable \( R \) that has a mean of \( \mu_R \) and a variance of \( \sigma_R^2 \). I assume that \( \mu_R \) may vary based on the venturing firm’s characteristics (see below) but that \( \sigma_R^2 \) remains constant across all firms; thus, no ventures are inherently riskier than others. The firm’s net present value calculation \( v_i \) is a noisy estimate of the venture value \( R_i \). The estimate \( v_i \) of the venture’s value is unbiased and can be written as \( v_i = R_i + \epsilon_i \). The random term in the estimate, \( \epsilon_i \), is normally distributed with a mean of zero and a variance of \( \sigma_\epsilon^2 \). Unlike \( \sigma_R^2 \), I assume \( \sigma_\epsilon^2 \) does vary based on firm characteristics. Some firms are more accurate evaluators than others.

Unlike much work in economic theory, I assume that the firm evaluating the venture does not know \( R_i, \mu_R, \sigma_\epsilon^2, \) or \( \sigma_R^2 \). The firm only observes the noisy estimate \( v_i \). This assumption is consistent with psychological theory, such as the “fundamental attribution error,” that has shown that individuals often cannot distinguish between results of their skills and random error (Ross, 1977). My model is consistent with bounded rationality (Simon, 1955) and does not incorporate any specific overconfidence biases that could lead to systematic excess entry and overinvestment (Camerer & Lovallo, 1999; Kalnins, 2005) or the attribution error (Ross, 1977). Yet the model does incorporate a subtle bias that I make explicit. The decision rule that a firm chooses to initiate the new venture if and only if \( v_i \) is greater than zero implies a high degree of confidence in its estimation ability and may deviate from rationality when an upfront resource commitment is required to initiate the venture. This assumption is consistent with the findings of Kahneman and Tversky (1982) that individuals are overconfident in their ability to make accurate predictions and continue to act based on these predictions, even when told about the existence of this bias.²

The model developed here is parsimonious and has explanatory value, but accuracy clearly has been sacrificed for parsimony. The model has not incorporated the fact that the decisions of firms may vary owing to cognitive biases, risk preferences, or environmental uncertainty. These well-understood phenomena present opportunities for extensions to the basic model.

Results Regarding Venture Success and Failure

As mentioned above, firms with estimates of \( v_i \) greater than zero will decide to initiate their new ventures, whereas those with negative \( v_i \) will not. Among those firms that initiate their new venture, firms with an actual net present venture value \( R_i > 0 \) will remain in business (will be successful), while those with \( R_i < 0 \) will shut down (will be failures). Because firms that estimate \( v_i < 0 \) select out of the sample by not initiating their new venture, an analysis of a truncated bivariate normal distribution is required to understand the relationship between a venture’s mean value \( \mu_R \) and variance \( \sigma_R^2 \) and the venture’s probability of success, given that the venture has been initiated, \( \text{Prob}[R > 0|v > 0] \).

¹ Note the differences between these assumptions and those of the standard Heckman model: using the labor force example, women may vary in their reservation wage (i.e., have different thresholds) but are presumed equally able to assess whether or not an offer of employment meets their threshold.

² This bias has been proposed as an explanation for the “winner’s curse” of behavioral economics (Thaler, 1992), in which the winner of an auction is likely to have overvalued an item—because he or she submitted the winning bid. A fully rational auction participant would evaluate the item and, realizing the likelihood of overvaluation, would reduce the bid. A participant overconfident in his or her own evaluation ability would submit a bid very close to the full valuation in a competitive auction.
Given the assumptions asserted above, two lemmas emerge regarding the outcome of venture success or failure. The first states a straightforward causal relationship between the actual mean net present value $\mu_{Ri}$ of a venture and the likelihood of success. In a hypothetical case where there is no selection, this lemma would be trivial. The important point is that even with selection (i.e., we observe only those ventures with $v_i > 0$), the relationship remains observable.

**Lemma 1:** As the mean venture value $\mu_{Ri}$ increases, the probability of venture success, $(\text{Prob}[R > 0|v > 0])$, increases. (See Appendix for proof.)

The second lemma demonstrates the effect of selection. In the presence of selection, even when holding mean venture value $\mu_{Ri}$ constant, a relationship emerges between the variance of the error term, $\sigma_v^2$, associated with a venture's estimated net present value and the likelihood of success. In a hypothetical case without selection, there would be no relationship because there is no causation. With selection, the firms able to estimate with a small error term the values of their possible ventures appear most likely to succeed, but only because of their more accurate selection into the sample; this group will typically initiate ventures with positive net present values. The subset of these small-error firms that have determined their potential ventures to be poor will not initiate their ventures and, thus, will not be observed failing. Firms with high-variance estimates of venture value are more likely to initiate ventures that are doomed to failure, specifically because of their imprecise estimation abilities.

**Lemma 2:** Holding mean venture value $\mu_{Ri}$ constant, as the variance of $\sigma_v^2$, decreases, the probability of venture success, $(\text{Prob}[R > 0|v > 0])$, increases. (See Appendix for proof.)

**Results Regarding the Average Estimate of Venture Value**

I present two lemmas that describe the effect of changes in mean venture net present value and error term variance on the value $E[v_i|v_i > 0]$, the expected value of a venture given that a firm has decided to initiate that venture. Like Lemma 1 presented above, Lemma 3 states that selection does not eliminate a relationship that would also be observed in the absence of selection. And like Lemma 2, Lemma 4 states that selection can create the appearance of a causal relationship, even though none would exist in its absence.

**Lemma 3:** As the mean venture value $\mu_{Ri}$ increases, $E[v_i|v_i > 0]$ increases.

**Lemma 4:** As the variance of the error term $\sigma_v^2$ decreases, $E[v_i|v_i > 0]$ decreases.

Maddala (1983: 168) provided the logical basis for these results and a sketch of their derivation. He developed these results in order to analyze regressions of truncated distributions. A full proof for Lemma 4 can be found in the Appendix of Denrell (2003).

An important distinction between the two sets of lemmas is that the causal (an increase in mean value) and selection (a decrease in variance) effects have the same implication for Lemmas 1 and 2 but opposing implications for Lemmas 3 and 4. For the outcome of venture success, then, the researcher will have difficulty distinguishing between causal and selection effects. For the analysis of observed venture value, the selection effect may cancel out a causal process that is, in fact, operating on the sample.

**Other Applications of Lemmas 1 Through 4: The Case of Survivor Bias**

I presented Lemmas 1 through 4 using estimated venture value $v$ as the variable based on which a firm selects in or out of a sample. In the case of survivor bias, the selection variable would be the dependent variable of success. Denrell (2003) applied Lemma 4 to the survivor bias case to show that if a researcher or firm is only able to observe surviving ventures, then, even with an identical expected value for all possible ventures before selection, those with the largest variance in value ex ante will have a
higher mean value after selection than those with a smaller variance.

**PREDICTIONS RELATING FIRM CHARACTERISTICS TO FAILURE**

To illustrate my two basic points—that selection can cause the appearance of a causal relationship where none exists and that selection may cancel out a real causal relationship—I analyze the selective effect of a firm's experience on the likelihood of venture failure and on the choice of initial resource commitment level. In a very broad sense, experience can include the previous initiation of similar ventures or the initiation of different ventures in culturally similar nations. For example, Pennings, Barkema, and Douma (1994), Barkema, Bell, and Pennings (1996), and Shaver, Mitchell, and Yeung (1997) found that a firm's previous international experience is positively related to the survival of its ventures abroad. Bane and Neubauer (1981) found that the international diversification efforts of large European corporations often failed when the diversification was unrelated to their core activities. This stream of literature has found benefits of cultural proximity similar to those found for experience (Barkema et al., 1996; Li, 1995). Such results are not surprising, because the managerial importance of the cultural distance construct is based implicitly on a type of experience; it assumes that the firm is experienced in its home nation and that cultural proximity will make the home nation experience beneficial in the nation that is host to the new venture. For these reasons, I refer to all these related phenomena generally as experience.

The literature on new product development has shown similar empirical associations of firm characteristics and failure. Many studies have reported a significant positive correlation of new product success with a high level of the firm's experience-based marketing skills, which include marketing research, advertising, and promotion, and with a high level of technical skills, including R&D, engineering, and production (e.g., see Brown & Eisenhardt, 1995; Calantone, Schmidt, & Song, 1996; and the references cited within).

Mitchell, Shaver, and Yeung (1994) group the mistakes that cause venture failure into two broad categories; ventures fail because (1) the firms make poor postentry decisions, or (2) the firms incorrectly evaluate the venture's potential value. The studies of FDI and new product development described above have focused only on the role of experience in reducing postentry mistakes. They have rarely considered the possible effect of experience on mistakes of the second category: experience may increase the firm's venture valuation accuracy. An experienced firm should have the greatest ability to select itself into a sample of initiated ventures only when its venture will, in fact, succeed.

**The Effect of Postentry Ability on Venture Success and Failure**

The hypotheses that the international business studies provide to explain the relation of venture failure to experience rely on the logic of improved postentry abilities—that is, the avoidance of Mitchell et al.'s (1994) first type of mistake. Experience with a type of product, a type of marketing channel, or a nation's culture decreases the costs of new ventures similar in those dimensions because fewer bad postentry decisions are made. The theoretical underpinnings of this logic come from learning-by-doing. While developed to explain the learning curve in production activities (Argote, 1999), variants of learning-by-doing theory have been used to argue that experience aids more complex activities, such as the operation of new ventures. Engaging in ventures similar to those conducted previously reduces search costs (March, 1991), leading to performance benefits in culturally similar markets (Benito, 1997). Further, routinization of operating procedures is an effective means of storing knowledge gained from experience (Argote, 1999; Fiol & Lyles, 1985; Nelson & Winter, 1982) and has resulted in higher-performing ventures (Pennings et al., 1994). Finally, firms may assemble a dedicated team to retain knowledge of mistakes made in previous ventures and, thus, avoid those mistakes in currently operating ventures (Kale, Dyer, & Singh, 2002). The common theme of these examples is that postentry costs and mistakes are reduced by experience.

Using the above logic, I assume \( \mu_{f1} \) increases with experience. A given venture will yield fewer mistakes, lower costs, and, thus, a higher mean value if initiated by an experienced firm rather than by an inexperienced firm. The firm's experience can be represented by the number of
previous ventures it has initiated. Because the literature says little about the accuracy of estimation, \( \sigma_{v_i}^2 \) remains constant. The following proposition emerges from Lemma 1.

**Proposition 1:** If a firm's experience leads only to better postentry decisions and not to better venture evaluation ability, the probability of venture success, \( \text{Prob}(R > 0|v_i > 0) \), increases as the firm's experience increases.

The intuition behind Proposition 1 can be gleaned from the two diagrams in Figure 1. The diagrams display the surface of a bivariate normal probability distribution (from above; the dotted shading indicates the areas that are of greater density) that represents the relationship between actual venture values \( R_i \) and the noisy estimates \( v_i \). The x axis represents the range of actual venture values available to each firm with a mean at the point \( \mu_R \). The firms do not know where their venture stands on the x axis but see only the imperfect estimate displayed on the y axis. Consistent with Proposition 1, the mean venture value \( \mu_R \) is greater for the experienced firm than for the inexperienced firm. To understand why the experienced firm is less likely to be observed failing, even after selection (the discarding of the part of the distribution that lies in Quadrants II and III), I focus on the success to failure ratio—that is, the ratio of the cumulative density in Quadrant I to that in Quadrant IV. The cumulative density of successful ventures (those in Quadrant I) is greater in the experienced firm than in the inexperienced firm, because as experience pushes up the mean venture value, it pushes ventures from Quadrant IV into Quadrant I (ventures that would have failed had a less experienced firm tried them), and it pushes ventures from Quadrant II into Quadrant I (good ventures that would not have been initiated by the less experienced firm). For the same reason, I also conclude that the cumulative density of initiated ventures that failed (those in Quadrant IV) is smaller in the experienced firm than in the experienced firm. Thus, the ratio of Quadrant I to Quadrant IV is greater for experienced firms than for inexperienced firms, and experienced firms are less likely to be observed failing even with selection present.

**The Selection Effect of Venture Evaluation Ability on Venture Success and Failure**

Here I describe the case of failure that is observed because firms have evaluated the venture incorrectly—that is, Mitchell et al.'s (1994) second type of mistake. While several works mention the importance of market evaluation when considering new ventures (e.g., Brown & Eisenhardt, 1995; Souder, Sherman, & Davies-Cooper, 1998), the mistake of poor venture evaluation rarely has been related to venture failure. In a lone exception, Quiggin (1992) proposed that initiation of agricultural ventures may have oc-

![FIGURE 1]

**Experience Raises Mean Project Value \( \mu_R \)**

\( v_i < 2 \text{ std. dev. from } R_i \)
\( v_i < 1 \text{ std. dev. from } R_i \)

Quadrant I: Firms initiate ventures \( (v_i > 0) \) that succeed \( (R_i > 0) \).
Quadrant IV: Firms initiate ventures \( (v_i > 0) \) that fail \( (R_i < 0) \).
Quadrants II and III: Firms do not initiate ventures \( (v_i < 0) \).
curred despite a negative venture value because of an error in evaluation. And the literature on expertise, while controversial in some domains (e.g., see Camerer & Johnson, 1991), has consistently found a relationship between estimation accuracy and experience in the managerial contexts of demand forecasting (Larreche & Moinpour, 1983) and new product introduction (Perkins & Rao, 1990).

A combination of Quiggin’s (1992) argument with this managerial forecasting literature suggests a compelling argument at the organizational level: less experienced firms should have a low ability to judge new venture value because they have received less feedback from previous ventures. Each potential venture has various observable characteristics, but because of limited previous entry experience, the inexperienced firm is not sure which characteristics are relevant and which are superfluous for determining venture success. To illustrate the mechanics of the process, I use the analogy of statistical regression: when making a go/no go decision, a firm implicitly “regresses” net present value of previous ventures on the observable firm and venture characteristics at the time each venture was initiated. The standard errors of the estimated coefficients \( \hat{\beta} \) of characteristics will decrease as the firm has more such data points, because

\[
SE(\hat{\beta}) = s \sqrt{\frac{1}{\sum (x_i - \bar{x})^2}}
\]

where \( s \) is the estimated standard deviation of the residuals, \( x_i \) are the values of the characteristics of the firm and its individual previous ventures, and \( \bar{x} \) are the mean characteristics across all the firm’s previous ventures (see Brooks, 2002: 123–127, for a complete derivation). The intuition that firms will make more precise estimates as they gain feedback from previous ventures comes from the fact that the summation \( \Sigma \) within the denominator of the above equation becomes larger as the sample size increases (i.e., the firm has received more feedback). Thus, the standard error becomes smaller as the firm engages in more ventures.

The prediction of the value of a future venture using the coefficients based on previous ventures will then be more precise, because \( \sigma_x^2 = \sigma_{x_i}^2 + \text{Var}(X \hat{\beta}) \), and \( \text{Var}(X \hat{\beta}) \) can be rewritten as \( X(SE(\hat{\beta}))X^T \) (Davidson & MacKinnon, 2004: 104). Thus, because \( SE(\hat{\beta}) \) decreases with experience, the variance of estimates of future ventures goes down as well. However, this logic says nothing about any benefit of experience for mean venture value, so \( \mu_{Ri} \) remains constant. The following proposition emerges from Lemma 2.

FIGURE 2
Experience Decreases Variance of Project Value Estimate \( v_i \).

3 Similar arguments have been made using Bayesian updating (Denrell, 2005; Gervais & Odean, 2001). While the aim of these models is to incorporate biases into decision making, an aspect not present here, they both confirm the notion that the variance of assessments will decrease with experience.
Proposition 2: If a firm's experience leads only to better venture evaluation ability and not to better postentry decisions, the probability of venture success, \( \text{Prob}(R > 0|v > 0) \), will appear to increase as the firm's experience increases.

Figure 2 illustrates the intuition behind this proposition. Consistent with the assumption underlying Proposition 2, the mean actual venture value \( \mu_R \) is equal regardless of experience, but the variance of the estimates is greater for the inexperienced firm, as illustrated Figure 2. To understand why the experienced firm is less likely to be observed failing after selection, I focus again on the success/failure ratio: the cumulative density of Quadrant I relative to Quadrant IV. The cumulative density of successful ventures (those in Quadrant I) is greater in the experienced firm than in the inexperienced firm because of the lower estimation variance for the experienced firm. As the firm gains experience and variance becomes smaller, as in the experienced versus the inexperienced firm in Figure 2, good ventures are pushed from Quadrant II into Quadrant I and are selected into the sample. Using similar intuition, I conclude that the cumulative density of initiated ventures that failed (those in Quadrant IV) is smaller in the experienced than in the inexperienced firm. As the variance becomes smaller, bad ventures are pushed from Quadrant IV into Quadrant III and are selected out of the sample. Thus, the ratio of Quadrant I to Quadrant IV for the experienced firm is greater than that for the inexperienced firm. Experienced firms are less likely to be observed failing due to selection.

To appreciate why selection is crucial here, note that if all ventures were initiated regardless of initial valuation \( v \) (i.e., selection did not occur), then the ratio of successes to failures would be the combined densities of Quadrant I and Quadrant II versus those of Quadrant III and Quadrant IV. Since the decreased variance only pushes ventures from Quadrant II into Quadrant I and from Quadrant IV into Quadrant III, the combined densities of Quadrant I and Quadrant II, and of Quadrant III and Quadrant IV, never change, regardless of variance.

Implications for Theory Development

The fact that Propositions 1 and 2 have identical observable implications for the relationship between experience and venture success presents an important challenge for researchers striving to generate, confirm, or extend a causal theory. Because selection is necessarily present in all samples of firms that choose to enter countries or new product markets, replications by different researchers cannot confirm the causally based theories, despite these researchers' beliefs to the contrary. A general implication of my model is that even though replication is typically a path through which detailed and useful theory can be confirmed and developed (e.g., see Popper, 1968, and Tsang & Kwan, 1999), sample selection effects will likely bias all replications in the same direction (Rosenbaum, 2001). Further, the standard approach of adding new independent variables to distinguish between causal and selective explanations will not work here either because the sample variable (firm experience) generates both outcomes.

Many academic fields have experienced debates regarding the value of disentangling intermediary effects if they have the same outcome. On the one hand, arguments exist that the accuracy of intermediary theory is less important than the ability to establish a predictable empirical regularity between variables (e.g., Friedman, 1953; Kuhn, 1962). On the other hand, scholars have argued that the "why" question is of central importance in academic research (Sutton & Staw, 1995; Whetten, 1989). Lawrence (1997) has stressed the significance for theory building of understanding intermediary processes, arguing that a lack of a clear understanding of all intermediary processes contributing to a consistently observed relationship between two variables stifles the benefits of the interplay between theory and method. In my context, academics have focused on the causal postentry mistake reduction explanation for the experience/success relationship. This focus has led to a call for more finely grained causal theory along the same lines, but no consideration of the selection effect.

Building proper theory unencumbered by selection biases is particularly important in a field of inquiry such as strategic management, which "is firmly grounded in practice and exists because of the importance of its subject" (Rumelt,
The practical importance of understanding new business ventures drives a demand for theory creation because, contrary to my initial hypothetical example in the introduction, venture failure is costly and pervasive. This practical demand can lead to less rigorous standards for theory being developed around the phenomenon (e.g., Whetten, 1989). For this reason, calling attention to selection effects within such contexts may be crucial to avoid heroic efforts in the pursuit of elaborate and detailed theories that are unwindingly built on shaky foundations.

**FIRM CHARACTERISTICS AND RESOURCE COMMITMENT**

To illustrate additional theoretical consequences of ignoring the selection effects of valuation ability, I develop two propositions regarding the level of firm experience that are based on Lemmas 3 and 4. I link experience to the size of firms’ initial resource commitments. In their seminal theory-building work, Johanson and Vahlne (1977) hypothesized that firms enter foreign markets incrementally—that is, they minimize resource commitments initially and increase those commitments as they gain experience. While substantial empirical evidence (discussed below) has emerged that contradicts this argument, I argue that a composite consisting of both causal and selective effects suggests a reconciliation of Johanson and Vahlne’s theory with empirical results.

**Inconsistent Empirical Results Regarding Experience and Resource Commitment**

Lemmas 3 and 4 related changes in mean value \( \mu_r \) and the variance of the error term \( \sigma^2 \) of a firm’s estimate to changes in the estimated values of those ventures that were actually initiated. I assume that the higher the venture’s estimated net present value, the larger the initial resource commitment, because the larger venture will involve more expenditures up-front. Ventures capable of generating a larger net present value may involve the construction of larger plants, greater financial commitment, greater allocation of managerial capacities, and so forth. I note that valuation based on percentage return (e.g., IRR) would not directly yield this relationship between value and resource commitment. However, even if ventures are selected using percentage return and not net present value, the relationship between the venture’s expected net present value and observed resource commitment will remain.

A number of papers have empirically evaluated the relationship between firm experience and the amount of resources committed up-front in a venture. The empirical results are mixed, with both experienced and inexperienced firms making large resource commitments. On the one hand, Johanson and Wiedersheim-Paul (1975), Juul and Walters (1987), Chang (1995), and Chang and Rosenzweig (2001) found that firms inexperienced in international transactions made limited resource commitments in early expansion attempts. They also documented cases of firms reducing commitments as they gained experience and reverting to exporting. Welch and Luostarinen (1988) discussed cases of small English firms, Australian start-ups, and established Swedish firms that skipped lower levels of commitment and were involved with unexpected speed in high-commitment direct foreign investments. Last, in Kalnins (2005), I found no relationship between commitments and experience.

**Poor Postentry Decisions and the Incremental Entry Hypothesis**

Johanson and Vahlne’s (1977) incremental entry hypothesis relies on the logic that experience increases the ability to make good postentry decisions. Firms lacking experience in international transactions will make minimal resource
commitments in their initial forays abroad because they are aware of their weak ability to manage postentry operations. An implicit assumption of the incremental entry hypothesis is that all firms, experienced and inexperienced, have an equal ability to judge the value of the ventures they consider.

Because it is based on postentry abilities, the theory of incremental entry implicitly assumes that \( \mu_R \) increases with experience while \( \sigma_e^2 \) remains constant. Firms with experience enjoy greater ability to make correct postentry decisions and, thus, will have higher net present value ventures. They will make greater resource commitments to support these valuable ventures. Given these assumptions, the following proposition emerges from Lemma 3 that will hold for samples of ventures that were initiated.

**Proposition 3:** If a firm's experience leads only to better postentry decisions and not to better venture evaluation ability, size of the initial resource commitment (a proportion of the value of \( E(v|v > 0) \)) will increase as a firm's experience increases.

As with Proposition 1, I provide intuition for this result using Figure 1. As shown, \( E(v|v > 0) \) is greater as the mean value of the ventures increases because of experience. Owing to selection, the sample only contains the cumulative density of ventures with \( v > 0 \) (i.e., Quadrants I and IV). The expected value is the horizontal line that would cut this density in half. As the mean venture value increases and more ventures end up in Quadrant I (and higher and to the right within Quadrant I), this cut must be made higher and higher to split the cumulative density in two equal halves.

### Varying Abilities to Appropriately Evaluate New Ventures

As mentioned above, some studies found that less experienced firms made greater initial resource commitments than their seasoned counterparts. The incremental entry hypothesis, some authors suggest, has not been supported empirically owing to theoretical contingencies not considered by the original authors. In subsequent work researchers have argued that the theory can be made more accurate by incorporating such issues as level of competition in the host country (Vahlne & Nordstrom, 1993), changes in government regulation regarding modes of entry (Sullivan, 1994), cultural entry barriers (Kwon & Huhn, 1995), initial firm size (Oviatt & McDougall, 1994), the attractiveness of the individual markets being entered (Mitra & Golder, 2002), and interactions among these contingencies (Lamb & Liesch, 2002).

I do not wish to discredit these possible contingencies, but I propose an alternative explanation based on the selection effect: experience may allow firms to better evaluate ventures. This possibility has not been considered in the large body of literature resulting from Johanson and Vahlne's (1977) seminal model. Firms with little experience will either make large negative or large positive estimates of their ventures’ net present values, but the negative estimates will not lead to entry. Among the firms that have initiated their ventures, firms with less experience should be observed making the larger initial resource commitments. Experienced firms enjoy the ability to evaluate their ventures accurately and will overestimate (and underestimate) resource commitments less often. For these reasons, a prediction opposite that of Proposition 3 follows.

**Proposition 4:** If a firm's experience leads only to better venture evaluation ability and not to better postentry decisions, the size of the initial resource commitment (a proportion of the value of \( E(v|v > 0) \)) will appear to decrease as the firm's experience increases.

As with Proposition 2, I provide some intuition for this result using Figure 2. As shown in the figure, \( E(v|v > 0) \) becomes lower as the variance of ventures decreases because of experience. In other words, firms become appropriately more conservative. As the variance of estimated venture value decreases, more and more ventures end up in Quadrant I, but their coordinate along the y axis will be low. The additional ventures entering Quadrant I will increase the density close to \( v = 0 \). And the ventures already in Quadrant I will be valued more conservatively.

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5 Johanson and Vahlne’s paper has been cited 510 times as of July 2007 (Social Sciences Citation Index).
Reconciliation of the Propositions and Findings of the Market Entry Literature

Propositions 3 and 4 help to reconcile discrepancies in the international business literature regarding incremental entry. On the one hand, because experienced firms are more likely to have ventures of high value from Proposition 3, they are more likely to engage in high levels of commitment. On the other hand, as less experienced firms who happen to enter are likely to overvalue their ventures (from Proposition 4), they are also likely to initiate ventures with large resource commitments. The mixed empirical results between firm experience and resource commitment are consistent with the possibility that both Propositions 3 and 4 are valid, but to different degrees. Consider for the last time Figures 1 and 2. Researchers will find a positive relationship between experience and resource commitment in cases where the experienced firm’s postentry ability, as shown in Figure 1, outweighs its accuracy in estimation, as shown in Figure 2. In other words, the causal experience-based gain in estimated venture value as shown by the difference between the levels of \( E(v|v > 0) \) in the inexperienced and experienced firms in Figure 1 is greater than the selective experience-based “loss” of \( E(v|v > 0) \) when going from the inexperienced to experienced firm in Figure 2. Other researchers will find a negative relationship in settings where the selective effect outweighs the causal effect.

In what settings might one or the other effect be dominant? I speculate that the causal effect will dominate in stable product markets. Postentry operational decisions will be harder to outsource and may still require substantial learning-by-doing. The selective effect should dominate when the variance in valuation is likely to be high, such as with new technologies or countries newly open for investment (e.g., the transition economies of Eastern Europe). In this case, precision in estimation could help experienced firms avoid excessive up-front investment, as long as their experience remains beneficial.

Before concluding, I highlight an alternate explanation for the mixed results in the international expansion literature that is also based on Lemmas 3 and 4. My model has assumed that all ventures are inherently equally risky—that is, they have the same actual variance in value. Firms’ experience decreases only the variance of their estimates, not the variance of the value itself. The alternate explanation would be to assume that the estimates of all firms have equal variance but that some ventures are riskier than others. In contrast to Johanson and Vahlne’s (1977) assumption, established firms may prefer less risky ventures, perhaps because they are concerned with maintaining legitimacy (Suchman, 1995) or because their search procedures are routinized (Cyert & March, 1992). Thus, as firms’ experience increases, they take on more conservative ventures. The ventures that are less risky ex ante will appear to have lower values after selection and will likely require smaller resource commitments.

LIMITATIONS AND EXTENSIONS OF THE MODEL

As I discussed earlier, I deliberately kept the model parsimonious to demonstrate sample selection effects in as simple a setting as possible. Naturally, I sacrificed accuracy. The model has not incorporated cognitive biases, risk preference, or changing environments and the associated competency traps. At a general level, selection issues will remain in all choice-based samples, such as those of FDI or new product development, regardless of the presence or absence of specific behavioral traits of the choosing firms. Some firms will remain better than others in their ability to evaluate potential ventures, and observers will see more successes among the good evaluators than the bad.

At a more detailed level, my model shows how selection could generate the appearance of a relationship between firms’ experience and likelihood of success. Overconfidence biases would likely exacerbate this selection-based relationship, because the inexperienced might exhibit this bias the most strongly (e.g., Gervais & Odean, 2001). Risk aversion might reduce the possibility of observing an experience-selection-success relationship because it may provide a reason for inexperienced firms to stay out of a market even if they estimated \( v > 0 \). A changing postentry environment would also

\[ I \text{ thank an anonymous reviewer for suggesting this possibility.} \]
likely reduce or eliminate the benefits of accurate venture valuation. The preentry evaluations may mean nothing in a changed environment, and, thus, there might be no remnant of a selective relationship between experience and success. Further, if the experienced firms fell into competency traps, the causal relationship between experience and success (the ability to avoid operating mistakes after entry) might be reduced or even reversed.

An intriguing extension to this model is suggested by Denrell (2003). He presented a model where firms—as opposed to the researcher—make mistaken inferences because of survivor bias. He proposed that firms learn vicariously (e.g., Miner & Haunschild, 1995) but that they may mistakenly believe markets to be worthy of entry because they are most likely to observe surviving firms; less information is available about failed entries. My current model does not incorporate vicarious learning. I have stated a simple selection rule based on which firms enter ($v > 0$) or not ($v < 0$). While the firms receive feedback from their own previous ventures (influencing both the mean and variance of $v$), the selection rule does not change based on any firm-level learning from others’ experiences, either directly or via researchers’ interpretations.

The focus of my paper has been on the misinterpretations made by researchers and the implications for theory development. Denrell’s (2003) survivor bias logic could be applied to sample selection. If firms neglected selection bias and tried to learn from others already in the market, excess entry may result. To understand why, consider again my unrealistic example from the introduction. If all the firms that entered a market initially did so because their estimate of $v$ was positive and completely accurate ($\sigma_v^2 = 0$), they would have all succeeded. Now imagine a second group of firms that did not enter initially. Like the naive researcher of the introduction, they see only successes and decide to enter, without actually evaluating their own ventures (evaluation is costly, after all). This would lead to excess entry, even though many ventures of the second group of firms will have a negative net present value and will fail. I leave development of this intriguing possibility for future work.

POSSIBLE SOLUTIONS

No simple empirical solution exists at this time for the type of sample selection I have described. The extent to which the sample selection problem remains in the data depends on how much information the researcher has about the data—in particular, about the portion of the sample that is selected out. Most econometric models that incorporate sample selection require at least some information about the observations selected out of the sample. Bloom and Killingsworth (1985) have developed an econometric model to take into account sample selection when no information whatsoever is available regarding observations selected out. But none of the standard existing models incorporate heteroskedasticity of the type I have described: the varying ability of firms to select in or out of a sample. For these reasons, the researcher analyzing quantitative secondary data is largely at the mercy of available data. At the very least, the sample selection issue should be acknowledged.

Researchers conducting case study research are perhaps in the best position to overcome sample selection biases. Case study methodologists (e.g., Eisenhardt, 1989; Glaser & Strauss, 1967) have discussed the need to not select cases randomly but, rather, to cover a broad enough spectrum of types of observation so that any consistent findings appear generalizable. At the same time, the incorporation of multiple observations of each type allows some degree of validation (Yin, 1994). Selection biases may be over- come by adding a category of observations not typically considered even in a case study that includes extreme types and polar situations: the firms that choose not to select into the sample of interest to the researcher. The case-based researcher interested in new product development or foreign market entry should incorporate into his or her analysis a group of firms that considered introducing a new product but chose not to, or that considered entering a foreign market but chose not to. A related strategy would be to investigate multiple go/no go decisions within the same firm. The researcher could study the process through which firms approved some potential ventures but not others.

Regarding the role of firm experience, the case-based researcher could establish whether the firms with less experience in market entry
typically have greater variance in their initial net present value estimations than do more the more experienced firms, as suggested in the propositions developed here. The researcher with detailed outcomes of several firms' valuation processes could compare similar ventures across firms to establish how the initial valuations varied, based on such firm characteristics as experience. For example, does a more experienced firm typically generate a more conservative estimate of a potential venture's net present value than an inexperienced firm? In a longitudinal study these initial estimates could be linked to subsequent venture performance and failure, ascertained either through the continuation of direct interaction with the participants or via publicly available information.

The same type of approach could be used for research designs based on surveys. By requesting data not only about ventures that did materialize but also about those under consideration, the researcher could establish the likelihood and direction of sample selection biases. One point here is that surveys are often not effective instruments for researchers to learn about venture failure. Firms often will not answer questions regarding failure or will understate the rate of failure of their ventures. This example highlights the value discussed by many authors of combining multiple sources, public and private, qualitative and quantitative, into a robust case study from which theory can be generated (e.g., Eisenhardt, 1989).

Finally, for researchers wishing to analyze large-scale data sets regarding the effects of experience, certain industries offer unique insights that may generalize to other settings where these insights would be obscured. For example, the large U.S. fast food franchisors (e.g., McDonald's, Burger King) make the initial go/no go decision regarding locating an outlet in a market but then usually assign the outlet to a separately owned franchisee (Kalnins & Lafontaine, 2004). The franchisor's experience is crucial for appropriate market selection but less important for postentry operations than is the experience of the franchisee. By examining performance implications within chains and thus holding market evaluation experience constant, the benefits of postentry experience (at the franchisee level) can be quantified more accurately.

CONCLUSIONS

Here I presented two insights for theory development from selection processes. First, I demonstrated that researchers wishing to build new knowledge should not conclude from accumulated empirical evidence that they (or others) have discovered a theoretically driven relationship before considering selection issues in the empirical setting. It is well known that multiple explanations may exist for any empirically observed relationship and that researchers need to collect additional data to distinguish among the multiple explanations before settling on any one theory to explain their findings. But theorists analyzing accumulated knowledge rarely consider that a selection process may be generating the available data and that this selection process may also be generating what appear to be relationships consistent with a theoretical explanation.

Second, I illustrated how selection issues may cause researchers to give up too fast on a parsimonious theoretical explanation that may be, to a large extent, valid. Researchers may believe that by observing contrary or inconclusive empirical evidence, they have cast doubt on an explanation that they had considered plausible a priori. While the development of an alternative theory or at least contingencies may appear to be the logical next step for the researcher, I argued that selection issues should be considered first. Selection effects may combine with causal relationships to generate patterns in the data that appear inconsistent with the actual cause of those relationships.

The issues are relevant both for inductive and deductive theorists. Inductive theorists in the quantitative and qualitative domains need to consider selection issues in their research setting before settling on a causal explanation for any observed relationships. Deductive theorists often use accumulated knowledge—that is, previous empirical findings and the theories supported or contradicted by the findings—as a starting point for new theoretical development. Empirical findings that appear inconsistent with existing theory provide the motivation to search for new theory. I encourage theorists to consider issues of selection before pursuing new theory development and before assuming that contingencies are required for the existing theory.

I analyzed two cases where exogenous firm characteristics could influence an outcome ei-
ther causally or via selection. In the case of selection, the exogenous characteristic may alter the likelihood that this instance is observable to the researcher because it alters the actor's ability to accurately self-select into observability. First, I demonstrated that in an analysis of firm experience on likelihood of venture failure, the selection effect is difficult to distinguish from the causal. Second, I presented a case where the causal and selection effects may cancel each other out. In the first case the inductive researcher may inappropriately conclude that a causal theory can be built based on the presence of a consistent empirical relationship. In the second case deductive theorists may inappropriately conclude that new theory or contingencies to existing theory are required to explain empirical discrepancies, while, in fact, the initial theory plus the effects of selection may sufficiently explain observed relationships within the data.

Beyond the general contribution to theory development, this paper has contributed to the literature on foreign market entry and the literature on new product development by contrasting the implications of the two types of mistakes discussed by Mitchell et al. (1994) that lead to venture failure. Failure may result because firms evaluate a venture's potential incorrectly or because they are unable to make postentry decisions. The literature has not paid sufficient attention to evaluation mistakes or to their implications for sample selection. The empirical relationship between resource commitment and firm experience lends credence to the proposition that firms often evaluate a venture's potential incorrectly—and it implies the worthiness of further study.

Finally, this paper has demonstrated the benefits of borrowing insights initially developed to improve statistical analyses and applying them to theoretical issues. Instead of using empirical data with observed outcomes to estimate coefficients, I have taken the principles and results of methodological theory and applied them to a theoretical problem. Further, the ways in which researchers make inferences regarding coefficient estimates provide a compelling analogy for how managers make decisions such as whether to invest in a new venture. I caution that this analogy should not be taken too literally; managers clearly are not statistical automatons but, rather, are subject to many cognitive biases and limitations. Nonetheless, using the well-accepted assumption of bounded rationality (Simon, 1955) allows us to tap into the wealth of results developed by statistical methodologists in order to create parsimonious theory with explanatory power regarding substantive problems.

APPENDIX

PROOFS OF MATHEMATICAL LEMMAS

Lemma 1: As the mean venture value $\mu_{Ri}$ increases, the probability of venture success, $(\text{Prob} \left[ R > 0 \mid v > 0 \right])$, increases.

$$
\text{Prob}(R > 0 \mid v > 0) = \frac{f}{f + h'} \quad \text{where}
$$

$$
f = \text{Prob}(R > 0 \cup v > 0) = \int_{0}^{\infty} (1 - F_{\epsilon}(-R)) f_{\theta} dR
$$

$$
= \int_{0}^{\infty} F_{\epsilon}(R) f_{\theta} dR \quad \text{(because $\mu_{\epsilon} = 0$)}
$$

$$
h = \text{Prob}(R < 0 \cup v > 0) = \int_{-\infty}^{0} F_{\epsilon}(R) f_{\theta} dR.
$$

Via the quotient rule,

$$
\frac{d(f/(f + h'))}{d\mu_{R}} = \frac{f'(f + h) - (f + h')f}{(f + h')^{2}} = \frac{f'h - h'f}{(f + h')^{2}},
$$

so to show that

$$
\frac{d(f/(f + h'))}{d\mu_{R}} > 0,
$$

I need to show only that $f'h - h'f > 0$, which is equivalent to

$$
\frac{f'}{f} > \frac{h'}{h}.
$$

To show that this inequality holds, I make use of the fact that $f' = \int_{0}^{\infty} (R - \mu_{R}) F_{\epsilon}(R) f_{\theta} dR$ and, similarly, $h' = \int_{-\infty}^{0} (R - \mu_{\theta}) F_{\epsilon}(R) f_{\theta} dR$. The inequality

$$
\frac{f'}{f} > \frac{h'}{h}
$$
becomes

\[
\left(\int_0^\infty (R - \mu_R) F_x(R) f_{\eta} dR - \int_0^\infty (R - \mu_R) F_x(R) f_{\eta} dR\right) / \left(\int_0^\infty F_x(R) f_{\eta} dR - \int_0^\infty F_x(R) f_{\eta} dR\right) > 0.
\]

\[
\int_0^\infty RF_x(R) f_{\eta} dR - \int_0^\infty \mu_R F_x(R) f_{\eta} dR > 0
\]

\[
\int_0^\infty F_x(R) f_{\eta} dR - \int_0^\infty F_x(R) f_{\eta} dR
\]

\[
= \int_0^\infty RF_x(R) f_{\eta} dR - \int_0^\infty \mu_R F_x(R) f_{\eta} dR
\]

\[
= \int_0^\infty F_x(R) f_{\eta} dR - \int_0^\infty F_x(R) f_{\eta} dR.
\]

The numerator in the left-hand side of the equation is clearly positive over the range of integration, while, on the right-hand side, it is clearly negative. The denominator on both sides is positive. As a result of these two observations, the left-hand side is greater than the right. Thus,

\[
\frac{d(f/f + h)}{d\mu_R} > 0. \quad \text{Q.E.D.}
\]

**Lemma 2:** Holding mean venture value \(\mu_{R_i}\) constant, as the variance of \(\varepsilon_v\) decreases, the probability of venture success, \(\text{Prob}(R > 0|v > 0)\), increases.

\[
\text{Prob}(R < 0|v > 0) = \frac{\text{Prob}(R < 0 \cup v > 0)}{\text{Prob}(v > 0)} = \frac{f}{g}, \quad \text{where}
\]

\[
f = \text{Prob}(R < 0 \cup v > 0) = \int_{-\infty}^0 (1 - F_x(-R)) f_{\eta} dR
\]

\[
g = \text{Prob}(v > 0) = \int_{-\infty}^\infty (1 - F_x(-R)) f_{\eta} dR.
\]

Via the quotient rule,

\[
\frac{d(f/g)}{d\sigma^2} = \frac{f'g - g'f}{g^2},
\]

so to show that

\[
\frac{d(f/g)}{d\sigma^2} > 0,
\]

I need to show only that \(f'g - g'f > 0\). Both \(g\) and \(f\) are positive, and \(g > f\) because the integration takes place over a wider range. Thus, I need only show \(f' > g'\) to conclude that

\[
\frac{d(f/g)}{d\sigma^2} > 0.
\]

\[
\frac{df}{d\sigma^2} = \frac{d}{d\sigma^2} \int_{-\infty}^0 (1 - F_x(-R)) f_{\eta} dR
\]

\[
\frac{dg}{d\sigma^2} = \frac{d}{d\sigma^2} \int_{-\infty}^\infty (1 - F_x(-R)) f_{\eta} dR
\]

\[
+ \frac{d}{d\sigma^2} \int_0^\infty (1 - F_x(-R)) f_{\eta} dR.
\]

by the rule of differentiation within an integral.\(^7\)

Now, I know that for \(R > 0\),

\[
\frac{d(1 - F_x(-R))}{d\sigma^2} < 0.
\]

\(^7\) See Salas and Hille (1982: 849).
Maddala (1983) states that

\[
\frac{d(1 - F_\phi(-R))}{d\sigma_e} = \frac{d(1 - \Phi(-R/\sigma))}{d\sigma} = -\frac{R}{\sigma^2} \Phi\left(\frac{-R}{\sigma}\right) < 0.
\]

Since \( \sigma > 0 \), an evaluation of the derivative of \( \sigma \) will yield a value of the same sign as the derivative with respect to \( \sigma^2 \). Thus, via a property of the definite integral,

\[
\int_0^\infty \frac{d(1 - F_\phi(-R))}{d\sigma_e^2} < 0. \tag{8}
\]

As a result, \( f' > g' \) and I can conclude that

\[
\frac{d(f/g)}{d\sigma_e^2} > 0
\]

and that a greater share of entrants have a venture value \( R < 0 \), and a smaller share have \( R > 0 \), when the variance of the error term is higher. Q.E.D.

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