No Exit:
Failure to Exit Under Uncertainty

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Delayed exit is a substantial economic problem. Studies indicate if VCs exited ventures optimally, returns would triple, and if corporations divested underperforming business units, GDP would increase 13.6%. A prevalent explanation for delayed exit is behavioral bias associated with escalated commitment. In general however exit will be "delayed" even absent bias. This arises from decision maker efforts to avoid Type I error while discovering the long run prospects of an endeavor. Solutions differ depending upon which source of delay predominates. However tests to date have been unable to disentangle the two effects. We attempt to do that.

While exit delays are problematic in numerous contexts, we examine them in the simplest real-world context—entrepreneurial exit of banks. Entrepreneurial exit comprises a well defined objective function (maximizing over choice over entrepreneurial profits versus wages) evaluated by a solitary actor with perfect incentives. Thus the context avoids problems of a larger (and generally unknowable to the researcher) opportunity set, as well as goal conflict and/or incentive misalignment among a group of non-owner managers. We decompose exit delay into a rational component (Bayesian updating under uncertainty) and behavioral bias. We find most of the delay in this context is rational. While we do find evidence of behavioral bias, results run counter to predictions for escalated commitment.

I. **Introduction**

The management and economics literatures pay substantial attention to entry decisions: what industries, markets and products firms should enter/introduce. Relatively little attention is paid to the obverse--exit. For example an ABI search on "entry" brings up 1553 articles whereas a search on "exit" brings up an order of magnitude less: 160 articles. This is curious since in equilibrium entry and exit should occur at roughly the same rate. Indeed, in the US, 3.0 million employer firms were created between 2000 and 2005, while 2.8 employer firms died over the same period.

If exit decisions were trivial, the lack of attention in the literature would be understandable, but there is substantial evidence that firms struggle with exit. The most salient anecdotal example is General Motors, whose shareholder equity is $-50 billion, but there is academic evidence as well. Guler (2007) for example finds the distinction between high performing and low performing venture capitalists (VCs) is not their ability to choose successful ventures, but their ability to terminate unsuccessful ventures. Her estimates indicate that if VCs exited ventures optimally, their returns would triple.

While the examples of exit from new ventures and new technologies are interesting they represent a small portion of economic activity. A far broader problem with exit is evident in the fact that the average diversified corporation trades at a discount of 20% relative to its breakup value. Since these corporations comprise 60% of US business assets, this suggests US GDP might be 13.6% higher if firms could exit their activities optimally.

The problem of course is two-sided. It is not simply the case that firms should exit earlier than they do. There are both type I and type II errors. Thus the complementary problem is that firms exit the wrong investments. Chesbro and Rosenbloom (2002) for example find the market capitalization of projects Xerox exited is three times that of Xerox itself.

While there are theories of market exit in Industrial Organization (Ghemawat and Nalebuff 1985, Fudenberg and Tirole 1986, Dixit 1989, Murto 2004) and evolutionary economics (Mansfield 1962, Nelson and Winter 1972), these pertain to optimal exit. Thus they do not account for the anomalies noted above. Indeed what constitutes "anomaly" is deviation from the predictions in these theories.

The notion of exit delay is introduced by Jovanovic 1982 who treats excess entry and exit delay as the outcomes of ability uncertainty.[1] Firms exit if their ability is below the market threshold, but they must operate in the market to learn their ability. Since our interest is in the anomalies or delays, we rely on the theories to define optimum, but we need additional theory to explain delay relative to optimum.

An alternative body of theory addressing exit delays is the organizational psychology on escalation of commitment (Staw 1976). Escalation of commitment refers to a class of phenomena with three characteristics: investment toward a goal, repeated decisions in the face of negative feedback, and uncertainty about outcomes. Under these conditions, actors seem slow to abandon their initial decisions. A number of theories have been advanced to explain escalation of commitment. Viewed from a Bayesian perspective, some of these pertain to strength of the priors, others pertain to interpretation of new information.

Mechanisms affecting the priors include the *sunk cost fallacy* (Thaler 1980)--the tendency to avoid losses from sunk investments despite their irrelevance, *anchoring* (Tversky and Kahneman 1974)-the tendency to rely too heavily on initial reference points, *status quo bias* (Samuelson and Zeckhauser 1988)--the tendency to maintain a behavior

[1] Note that ability uncertainty alone is insufficient to generate excess entry. Camerer and Lovallo (1999) show that absent overconfidence in ability, there is no excess entry.

unless there is a compelling reason to change, and *overconfidence* (Roll 1986)--the tendency to overestimate one's own ability.[2]

Mechanisms affecting the use of new information include *prospect theory* (Kahneman and Tversky 1979)--the tendency to treat losses differently than gains, self-serving *attribution bias* (Miller and Ross 1975)--the tendency to treat successful outcomes to one's own skill and unsuccessful outcomes to bad luck, *confirmatory bias* (Lord, Ross and Lepper 1979) -- the tendency to interpret information in a way that confirms preconceptions, and *motivated reasoning* (Kunda 1987)--the tendency to accept desirable information, but scrutinize undesirable information.

Both bodies of theory (evolutionary economics and organizational psychology) inherently view exit delay as a problem of detection under uncertainty. Accordingly, tests examining exit delay as a function of uncertainty levels or signal volatility tend to support either view, and are unable to disentangle the two effects. However, since the two theories have differing prescriptive implications for government policy and firm strategy, it is important to discriminate between them.

We build an empirical model that decomposes exit delay into "rational" attempts to minimize Type I error in the presence of noisy performance signals versus behavioral bias in responding to those performance signals.

We test the model in the context of entrepreneurial exit by independent banks. We chose this context for a number of reasons. First, the principal cause of bank failure is high cost relative to rivals, thus the failure mechanism matches that in economic theories of exit. Second, the FDIC provides complete quarterly financial data for the full census of US banks, thus we know what signals each bank observes, and we can also estimate "relative cost" in each period (the signal

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[2] There is confusion in the literature regarding overconfidence and optimism In some instances overconfidence refers to the accuracy of one's estimates (Fischoff, Slovic and Lichtenstein 1977); in others it refers to overestimating own ability. There is also similar confusion regarding optimism: optimism regarding outcomes generally (Heath and Tversky 1991), versus optimism about outcomes of own effort. We follow the convention that overconfidence refers to estimates of own ability.

they are trying to detect) Finally, banks are distributed across fifty US markets which differ in the levels market uncertainty (demand volatility and ability uncertainty (cost distribution). Accordingly we can estimate the impact of each type of uncertainty on exit delay.

Our results in that setting suggest most delay can be attributed to rational efforts to avoid type I error. In particular, delays decrease in the magnitude of the underlying signal (own cost) and increase with noise. However we do find some evidence of behavioral bias. Entrepreneurs in this setting appear to have asymmetric responses to positive versus negative information and to market uncertainty versus ability uncertainty. In particular, exit accelerates in the proportion of negative signals (above and beyond the effect of cumulative losses). Similarly, exit accelerates in the ex ante market uncertainty (demand volatility) but is delayed by ability uncertainty. Neither asymmetry is expected under a rational detection model. Furthermore the direction of bias in both cases is opposite to predictions under escalated commitment. Thus entrepreneurs in this setting appear to be *increasing* their risk of Type I error.

The paper proceeds as follows. First, we review the economics and organization psychology literature on exit. Next, we develop an empirical model to decompose the two effects. We describe the empirical test of that model, then discuss results and implications for both public policy and firm strategy.

2. Theories of exit

The introduction makes clear that exit decisions occur in many contexts and at many levels of analysis: venture capitalist exit from ventures, corporate exit from business units or markets, abandoning R&D projects, employees leaving firm, individuals selling stock and spouses leaving marriages (Thompson 2008). While these decisions share common elements, they tend to have idiosyncratic elements as well. The easiest means to compare them is to think of exit decisions as having nested complexity. At the core is “ideal” exit by a unitary and unbiased actor under perfect information, e.g. Ghemawat and Nalebuff's (1985) model of optimal exit from a duopoly in a declining industry.

Complexity increases as we introduce uncertainty. Uncertainty tends to change results relative to Industrial Organization (IO) models without uncertainty. Both Fudenberg and Tirole (1986) and Murto (2004) generate conditions under which the order of exit is reversed relative to Ghemawat and Nalebuff. In the case of Fudenberg and Tirole the uncertainty pertains to rivals' opportunity cost; in Murto uncertainty pertains to the evolution of demand. Dixit (1989) treats demand uncertainty when firms must incur an additional entry fee if they re-enter the market. In this model firms may delay exit beyond the point of negative profits due to the option value of avoiding re-entry costs. Thus uncertainty changes both the timing and order of exit.

This "level of complexity" is also reflected in models from evolutionary economics. Nelson and Winter (1982) and Jovanovic (1982) both consider uncertainty regarding the firm's true cost. This uncertainty "delays" exit until firms recognize their true cost from a stream of cost signals. In Jovanovic, underlying cost and price are fixed. In Nelson and Winter, both price and cost evolve as firms make stochastic investments to reduce cost.

The next level of complexity retains solitary actors with perfect incentives, but introduces human decision makers who are subject to behavioral bias. This is the first "real-world" level, and thus captures entrepreneurs or individual investors acting on their own behalf. Finally at the greatest level of complexity are multiple decision makers, as in the case of venture capital funds and public firms. Multiple decision-makers adds the classic problems of organizational economics, such as agency problems of non-owner managers, and problems of joint decisions with multiple stakeholders.

Because we are interested in isolating the effects of rational efforts to minimize Type I error vesus behavioral bias, we consider the simplest form of real-world exit--entrepreneurial exit. Thus we consider exit under uncertainty by actors with perfect incentives but potential behavioral biases. We examine whether the timing of entrepreneurial exit conforms to a rational model of noisy selection, or whether exit exhibits additional delays associated with behavioral bias. Note that other models of exit share many attractive features of Jovanovic, but consider more complex settings: Nelson and Winter (1982) and Ericson and Pakes (1995) examine industries where firm cost changes over time due to R&D investment. There is empirical evidence to support each model in particular settings, e.g., Pakes and Ericson (1998) find retail to be consistent with Jovanovic's model of constant cost, while manufacturing is better matched to a model of evolving cost. Thus choice of model is one of match to context. Due to our interest in understanding exit under low complexity (and in understanding contexts with entry and exit in steady-state), we favor Jovanovic, and choose an empirical setting matched to its assumptions.

2.1. Noisy selection

Jovanovic (1982) offers a theory of noisy selection to explain deviations from Gibrat's law. The theory considers an atomistic industry (infinite number of firms and potential entrants, each of measure zero so that each is a price taker). Firms and potential entrants know the entire equilibrium price sequence and the distribution of firm cost, but potential entrants face ex ante uncertainty regarding their own cost. Firms pay a sunk cost to enter the market, then begin receiving noisy signals about their true cost. Firms exit if and when they learn the expected value of profits (given updated beliefs about their true cost) is below the opportunity cost of exit. This results in an equilibrium in which price is constant over time and entry and exit occur in each period. This model is appealing for a number of reasons. First, its assumption regarding known cost distribution, but ex ante uncertainty regarding own cost matches empirical reality in at least one industry (Wu and Knott 2007). Second, its expectations regarding the size distribution of firms match empirical reality across a number of industries. Finally, it is the only model to our knowledge that anticipates the churn characterizing most US industries. On average firms enter the economy at an annual rate of approximately 11% of incumbents and exit at a rate of approximately 10% of incumbents.

Because Jovanovic is interested in patterns of entry, exit and growth in an industry, his propositions pertain to aggregate market dynamics. However a compatible model of the firm level decision comes from Ryan and Lippman (2003). Ryan and Lippman (RL) present a model capturing the firm's decision to exit a project (market in our context) given noisy signals about its underlying profits. Here forward we use firms rather than RL's projects. The model assumes firms are of two types: with probability p_0, firms are profitable, and have underlying profit rate, μ_H. With probability 1- p_0 they are unprofitable, and have underlying profit rate, μ_L. The underlying profit rate is unobservable, but firms receive noisy signals of profits over time. The signal comprises the underlying rate plus a noise component with variance σ^2. Cumulative profits, X_t, thus exhibit Brownian motion with drift μ and variance σ^2. The firm maximizes expected discounted profit in each period by choice of exit.

The firm knows the value of μ in each of the two states and the aggregate probability, p_0 of being in the high state, but does not know is own state. The firm's posterior estimate of being in the high state at time t, P_t, is a function of cumulative profits, X_t, signal volatility, σ, the profit rates in each state, μ , and the discount rate, α, but is independent of the pattern of profits. RL derive the optimal stopping time, t as the first time at which cumulative profits, X_t, fall below threshold:

$$X \leq -\left[\frac{\sigma^2}{\mu_H - \mu_L}\log\left(\frac{\mu_H p_0 (\gamma+1)}{-\mu_L (1-p_0)(\gamma+1)}\right)\right] + \frac{\mu_H + \mu_L}{2} t \qquad (1)$$

with

$$\gamma = \sqrt{1 + \frac{8\alpha\sigma^2}{(\mu_H - \mu_L)^2}}$$

One interesting and potentially controversial feature of the RL model is that signal volatility decreases the value of the venture because it impedes learning. In contrast, for Dixit (1989) volatility increases the expected profits due to the option value of exit. Thus in addition to testing for exit delay, we can implicitly test whether exit behavior conforms to an options model or a learning model.

2.2 Escalation of commitment

The organizational psychology literature most relevant to exit is Staw's work on escalation of commitment (Staw 1976, Staw and Ross 1978). Escalation of commitment describes a class of phenomena sharing three features: investment toward a goal, repecated decisions in the face of negative feedback and uncertainty about outcomes. Staw and Ross identify and conduct a critical test of six theories/psychological mechanisms that would account for escalation of commitment*: expectancy theory, illusion of invulnerabillity*, *reactance effect*, *reinforcement theory*, *learned helplessness* and *self-justification*.

Expectancy theory (Lewin 1938) is the psychological term for rational (utility maximizing) behavior. Individuals choose the course of action that has the highest expected utility. *Illusion of invulnerability* (Janis 1972) is excessive optimism. The *reactance effect* (Brehm 1966) is a tendency to work harder when faced with a setback, so as to improve future outcomes. *Reinforcement theory* (Skinner 1953) refers to a tendency to repeat actions associated with positive outcomes (and conversely to abandon actions associated with negative outcomes). *Learned helplessness* (Seligman 1975) is perceived absence of control over outcomes. Finally, *self-justification* refers to behaviors to restore self-esteem following a set-back. One such behavior is perceiving the setback as due to external factors rather than to own ability or behavior (Weiner et al 1971); another is to distort the magnitude of the setback (Festinger et al 1956**).**

Thus the combination of mechanisms suggests that individuals will recommit to a course of action regardless of the outcome (positive outcomes will cause them to recommit under reinforcement theory, whereas negative outcomes will cause them to recommit under illusion of invulnerability, reactance, learned helplessness and self-justification). This tendency to recommitment regardless of outcomes has been labelled *self-serving attribution bias*--attributing positive outcomes to one's own ability or behavior and negative outcomes to external factors.

There have been a number of tests of these mechanisms in the organizational psychology literature. In general there doesn't seem to be support for self-serving attribution bias. Staw and Ross (1978), for example, conduct a clever experiment where subjects are assigned an outcomes history as well as a setback that is desribed as being either endogenous or exogenous, then asked whether they want to recommit to the course of action. Under these conditions results support expectancy, invulnerability and reactance, but reject reinforcement, learned helplessness and self-justification mechanisms.

Miller and Ross (1975) in a literature review of self-serving biases in the attribution of causality conclude that some data are consistent with self-enhancement, but there is minimal support for self-protection. Finally, Malle et al (2007) conduct a meta-analysis of 173 studies of a closely related phenomenon: actor-observer asymmetry in the attribution of causality. The asymmetry pertains to actor tendency to attribute actions to situational requirements versus observer tendency to attribute the same actions to stable personality dispositions. They conclude that the causal mechanism receiving the strongest support is reason asymmetry—actors (because reasoning entered into their decision) use more reasons and fewer causale history explanations for behavior and outcomes. In addition they engage in impression management—they choose rational that are self-flattering in an effort to influence audience perceptions. Thus the studies since Staw and Ross tend to find support for self-justification, though in a slightly different mechanism and in a different context (retrospective causality rather than internalization of the retrospection for purposes of prospective decisions).

The finance literature has adopted behavioral theory as a means to explain asset pricing distortions, beginning with Roll's (1986) hubris hypothesis of acquisition prices. While Roll applied the hubris construct to firm behavior, more recent work (Daniel, Hirschleifer and Subrahamanyan 1998, Barber and Odean 2001 and 2002) has applied the notion of overconfidence to explain anomalous investor behaviors such as excessive trading. One question is whether overconfidence is inate or developed. Gervais amd Odean (2001) argue overconfidence, much like escalation of commitment, is developed through self-serving attribution bias applied to sequential decisions with noisy feedback.

This adoption of self-serving attribution bias as an explanation for investor behavior is somewhat surprising given its weak support in the organizational psychology literature. Nevertheless, Choi and Lou (2007) test the hypothesis using data from active fund managers. They operationalize overconfidence as both deviations from a benchmark portfolio as well as turnover ratio; self-serving attribution bias as volatility of past returns, and true ability as subsequent returns. They find a) that volatility increases both measures of overconfidence, and that its effect is larger than past performance. The logic for using volatility as the measure of self-serving attribution bias is the asymmetry in response to feedback—individuals revise their self-perceptions upward more in response to positive signals than they revise self-perceptions downward in response to negative signals. The concern with this implementation is that volatility is also a measure of noise—thus self-serving attribution bias cannot be distinguished from rational delays associated with information quality (a la Jovanovic). In addition to the concern with the proxy, is the concern that fund managers are agents, thus they have asymmetric incentives—rewards are higher for positive outliers than punishments for negative outliers.

Ko and Hansch (2008) solve the agency problem through an experiment where decision makers were sole claimant to rewards. Subjects repeated double or nothing bets on whether their preferred stock relative to another stock would have higher returns. Thus the experiment deals with overconfidence in beliefs rather than in ability. They found that subjects' reports were positively biased for favored stock, and that reports were more distorted for losses than gains. The bias manifested itself not only in reported perceptions, but in investment beahvior as well.

These results were interpreted as support for self-serving attribution bias as well as *confimatory bias* (Lord, Ross and Lepper 1979) and *motivated reasoning* (Kunda 1987).

3. Empirical Test

To decompose exit delay into its rational and behavioral components, we examine entrepreneurial exit across fifty markets in the US banking industry using an accelerated failure time model. We model exit timing as a function of firms' true cost, two sources of ex ante uncertainty, two forms of ex post performance signals and a wealth constraint while controlling for time varying market characteristics. We also control for economy-wide conditions using year effects.

3.1 Industry

We conduct our tests in the banking industry following de-regulation. The industry was chosen because it exhibits substantial entry and exit (on an absolute basis rather than a relative basis) (see Figure 1), and because the mechanism of exit (inefficiency) matches the mechanism in economic models. In addition the setting controls for heterogeneity in entrepreneurs' utility functions and opportunity costs (Gimeno, Folta, Cooper and Woo 1997). In particular, the human capital necessary to gain a charter is banking specific, thus the outside employment opportunity under failure is a banking executive. Moreover banking is highly professionalized, thus the amenity potential and psychic benefits of banking entrepreneurship are comparable across firms.

Insert figure 1 about here

Finally, the industry is fragmented with localized competition. Fragmentation is important because it allows us to compare discrete markets within the same industry. Thus we can compare differences in ex ante uncertainty while controlling for other factors affecting cost across distinct industries. We can also control for differences in level of demand through differences in economic conditions across markets. Finally, the industry has comprehensive quarterly financial data for the full census of insured banks (over 99% of all banks).

3.2 Empirical Model

Following equation 1, we model exit timing as a function of firms' true cost and a number of factors affecting time required to determine its cost is above the market's cost threshold (or its expected profit is below the opportunity cost of exit). Equation 2 tests for exit timing as a function of firms' true cost, market mean cost, two sources of ex ante uncertainty (demand and cost), ex post performance signals, cumulative profits, which serve both as the optimal stopping point and as a wealth constraint, and the option value of avoiding re-entry, while controlling for time varying market characteristics, X_{jt} and year effects, δ_t. The year effects allow us to control for economic conditions, e.g., cost of capital and quality of the acquisition market, that vary over time.

$$t(exit)_{ijt} = \beta_0 - (\beta_1 c_{it} - \beta_2 \mu(c)_{jt}) + \beta_3 q_{it} + \beta_4 \sigma(c)_{jt} + \beta_5 RMSE(Q)_{jt} + \beta_6 \Sigma_t(\Pi)_{it} + \beta_7 \sigma_t(\Pi)_{it}$$
$$+ \beta_{8it} (\Sigma(t)(\Pi_t<0)/(\Sigma(t)(\Pi_t>0)) + \beta_9 w_{jt} + \beta_9 K_{jt} + \beta_{10} X_{jt} + \delta_t \qquad (2)$$

where:

c_{it}	=	firm cost relative to a global frontier (Knott and Posen 2005)
q_{it}	=	firm specific demand (loans)
Q_{jt}	=	market demand (loans)
Π_{it}	=	firm profits
$\Sigma(\Pi)_{it}$	=	cumulative profits
$\Sigma t{:}\Pi_{it}<0/\Sigma t{:}\Pi_{it}>0$		loss ratio (periods of losses/periods of gains)
w_{it}	=	market wage
K_{it}	=	entry cost
X_{it}	=	vector of time varying market characteristics

Note there are two options in banking that potentially offer value of remaining in the market after determining true cost is above threshold. We test directly for the option value of avoiding re-entry costs if the market improves (Dixit 1989). The other option in this setting is being acquired by a bank holding company. There was substantial consolidation in the industry during the period we examine (Figure 2). We control indirectly for this option value via year effects.

Insert figure 2 about here

We test Equation 2 using an accelerated failure time model (Stata procedure streg). The model implicitly tests the impact of correlates relative to mean failure time. Accelerated failure time models are used in health care studies where the field is interested in expressing the impact of treatments as extended life span rather than hazard of death. Positive coefficients are interpreted as extending time to fail. AFT models are parametric, thus we must specify a distribution for the error term. Our primary distribution is Weibull, however we also test alternative forms.

Under conditions of perfect information, all firms above the cost threshold in the market should exit the market once their demand approaches steady state. Under rational exit delay, we expect firms' ability to detect their true cost (and thus exit) to increase with the magnitude of the signal (distance between their cost and mean market cost) and with cumulative profits, and to decrease with demand volatility and cost uncertainty. Thus we expect β_1 to be negative and significant, and β_2, β_4,, β_5, β_6 *and* β_7 to be positive and significant.

In addition, if entrepreneurial decisions are subject to self-attribution bias, we expect β_8 to be positive and significant. Apart from the noisy selection components, we expect exit to accelerate when firms face wealth constraints and high opportunity cost. Thus we expect β_9 and

β_{10} to be negative and significant. (Note that β_6 captures the wealth constraint through cumulative losses).

3.3 Data and variables

Data for the study come from the FDIC Research Database which contains quarterly financial data for all banks filing the "Report of Condition and Income" (Call Report). This initial data set contains 694,587 firm-quarter observations (all banks in each of the fifty states plus the District of Columbia for the period 1984 to 1997). From these, we restrict attention to the 1456 banks who fail during the period, where failure follows the FDIC definition of a "paid-out" or a "forced merger". This yields 28,347 firm-quarter observations

From the set of raw variables in the data base, we derive the variables used to test equation 2. The dependent variable is the number of quarters until failure. (Figure 3 is a histogram of periods until failure).

Insert Figure 3 about here

The RL model characterizes optimal exit using continuous draws of profit signals from a binomial distribution. In contrast our data reflects discrete draws from a log-normal distribution. The timing of draws is presumed innocuous. The larger concern is treating all firms above threshold as sharing the same profit rate, and treating all firms below threshold as sharing the same profit rate. While firms who fail do tend to have a meaningful underlying profit rate, the profits of those who succeed tend to grow over time due to reinvestment (Figure 4). Without a meaningful value for μ_H it is not possible to define X*. Accordingly rather than testing delay relative to an optimum, we test the constructs contributing to the optimum (as were captured in equation 2).

Insert Figure 4 about here

The *cost* variable is the measure of firm cost relative to a global frontier derived in Knott and Posen (2005). The *demand* variable follows convention in the banking literature and thus is captured as loans ($1000). Profits are defined as quarterly net income ($1000). Our measure of *ex ante demand uncertainty* is the RMSE for market-specific regressions of loans versus a 10 year time trend. Our measure of *ex ante ability uncertainty* is the market-year specific standard deviation of firm cost. Our measures of *ex post uncertainty* are the firm specific standard deviations of loans and of profits for the periods the firm is in the market. *Cumulative profits* is the running sum of net income (on the negative side it is also a proxy for the wealth constraint). Our measure of *opportunity cost* is the market wage derived from the FDIC data. The time-varying *market characteristics* (population, building permits, market size and firms in market) are derived from census data. The measures control for differences in economic conditions and market structure across markets. We control for economy wide conditions affecting opportunity cost (primarily the cost of capital) and the option value of remaining in the market (primarily the opportunity to be acquired) through year effects. These data are summarized in Table 1.

Insert Table 1 about here

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4. Results

Results for decomposing exit delay are presented in Table 2. Regarding the rational component of efforts to minimize Type I error, the results support a model of noisy selection.

With respect to the cost signal, the coefficient on firm cost is negative, indicating that exit accelerates as cost increases. This occurs because it is easier to detect signals that differ significantly from the mean (the coefficient on mean market cost is insignificant—this is because mean cost does not vary much across markets). Delay is also accelerating in cumulative losses (positive coefficient on cumulative profits). With respect to noise, the coefficients on ex ante and cost uncertainty and ex post profit volatility are both positive, reflecting greater difficultly to detect ability in high noise.

Insert Table 2 about here

While the results support noisy selection, they also exhibit evidence of bias. In particular there is asymmetry between ability uncertainty and demand uncertainty, as well as asymmetry in treating gains versus losses. In a departure from expectations, the coefficient on ex ante demand uncertainty is negative (the coefficient on ex post demand uncertainty is insignificant). This is unanticipated by either the rational model or escalated commitment. Rather, the result is more consistent with prospect theory or risk aversion.

The coefficient on negative periods is positive, but the coefficient on loss ratio is negative. The significance of negative periods may be an artifact of construction (periods necessarily increases with negative periods). Thus the main attribution variable (loss ratio) accelerates exit, rather than the delays it. This variable may be contributing to the wealth constraint, but remains significant in its presence. Nevertheless, the result conflicts with attribution theory expectation that actors discount negative information relative to positive information.

Thus results tend to support a model of noisy selection. The signal and the noise variables behave in the manner expected. While results also show evidence of behavioral bias, the bias is inconsistent with escalated commitment. Instead, results suggest prospect theory or risk aversion—both of which will tend to increase Type I error.

5. Discussion

Delayed exit is a substantial economic problem. Studies indicate if VCs exited ventures optimally, returns would triple, and if corporations divested underperforming business units, GDP would increase 13.6%. A prevalent explanation for delayed exit is behavioral bias associated with escalated commitment. In general however exit will be "delayed" even absent bias. This arises from decision maker efforts to avoid Type I error while discovering the long run prospects of an endeavor. Solutions differ depending upon which source of delay predominates.

While exit delays are problematic in numerous contexts, we examine them in the simplest real-world context—entrepreneurial exit of banks. Entrepreneurial exit comprises a well defined objective function (maximizing over choice over entrepreneurial profits versus wages) evaluated by a solitary actor with perfect incentives. Thus the context avoids problems of a larger (and generally unknowable to the researcher) opportunity set, as well as goal conflict and/or incentive misalignment among a group of non-owner managers.

Consistent with both theories, we find that noise delays exit relative to a world with perfect information. A 10% increase in market cost dispersion delays exit by approximately seven weeks. Volatility of the firm's profits further delays exit.

While this result is anticipated by both theories, we were able to decompose exit delay into a rational component (Bayesian updating under uncertainty) and behavioral bias. We accomplished this using the constructs from the Ryan and Lippman model. We found that most of the delay in this context is rational. Thus we find support for the Jovanovic (1982) model of noisy selection.

We also found asymmetric response to ex ante demand uncertainty versus ability uncertainty, and to expost signals of profitability (losses versus profits). While this suggests behavioral bias (since all noise should be treated similarly under a rational model), the bias accelerates rather than delays exit. Demand uncertainty decreases time to exit as does the ratio of negative signals. Since both of these effects are net of cumulative profits, entrepreneur behavior appears more consistent with risk aversion and prospect theory than escalated commitment.

These results pertain to exit from entrepreneurial banks. While we chose this setting because it controlled for a number of factors, it is worth considering how banking differs from other contexts. First, banks require charter approval. This process requires founders have substantial financial capital (approximately $11 million) and high levels of industry specific human capital. Thus entrepreneurs' decisions in this setting may be more rational than in other settings—both because they regularly make decisions based on noisy quantitative data and because the financial stakes are larger. The large financial stakes may explain the unanticipated risk aversion result. Escalated commitment may play a role in other settings.

Second, banking comprises a large number (approximately 10000) of homogeneous firms, with high frequency (quarterly) and high resolution (2400 variables) public data on the full census of firms. Thus noise is extremely low relative to other settings. In fact, the efficiency of exit from this setting may stem in large part from data quality. If other settings exhibit substantial exit delays, one prescription might be for governmental disclosure of census and tax data for all firms. While this ordinarily poses concerns about competition and innovation, the experience in banking suggests these may be overstated.

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Table 1. Data summary

Variable	Mean	Std.	Min	Max
u_tn_pl	0.262	0.256	0.010	3.491
rloans	146.088	234.572	-983.000	999.000
cumprof	428.974	2284.848	-8670.000	19798.000
med_wage	2.983	0.106	2.721	3.397
rmse_bizcy~n	0.023	0.009	0.009	0.109
sd_ln_u_tn	0.596	0.100	0.102	1.316
ag_ln_u_tn	-1.782	0.275	-2.709	-0.717
gdp	305086.200	236940.400	9822.885	973395.000
population	11700000.000	8279413.000	476966.000	32500000.000
permit	73201.940	74548.330	132.000	314641.000
mkt_size	136000000.000	110000000.000	4105690.000	664000000.000
mkt_firm_c~s	945.650	735.973	11.000	1997.000
negper	4.084	4.497	0.000	42.000
losratio	0.338	0.303	0.000	1.000
sigprof	238.077	131.978	0.000	981.580
sigloan	177.123	96.135	0.000	860.549

Table 2. Results

Dependent variable = periods to exit
observations =1476

	1	**2**	**3**
cost	**-0.3268**	**-0.2432**	**-0.1224**
	0.0408	0.0336	0.0153
loans	**-0.0002**	**-0.0002**	**-0.0001**
	0.0001	0.0000	0.0000
cumulative profit		**0.0001**	**0.0000**
		0.0000	0.0000
median wage		**0.5040**	0.0491
		0.1067	0.0697
demand volatility		**-4.9144**	-0.7017
		0.9135	0.4559
Π(cost)		**0.7365**	**0.2506**
		0.1262	0.0557
Π(cost)		0.0401	-0.0132
		0.0397	0.0221
gdp			0.0000
			0.0000
population			0.0000
			0.0000
permit			**0.0000**
			0.0000
market size			**0.0000**
			0.0000
firms in market			0.0000
			0.0000
negative periods		**0.0315**	**0.0183**
		0.0042	0.0022
loss ratio		**-0.5965**	**-0.3553**
		0.0754	0.0389
Π(profits)		0.0002	0.0001
		0.0001	0.0000
Π(loans)		-0.0002	0.0000
		0.0001	0.0001
year effects			**included**
_cons	**3.2268**	**1.4750**	**1.6410**
	0.0217	0.3193	0.2074
Log likelihood	-1085.7000	-729.7000	-600.0300

Figure 1. Levels of churn in banking over the period examined

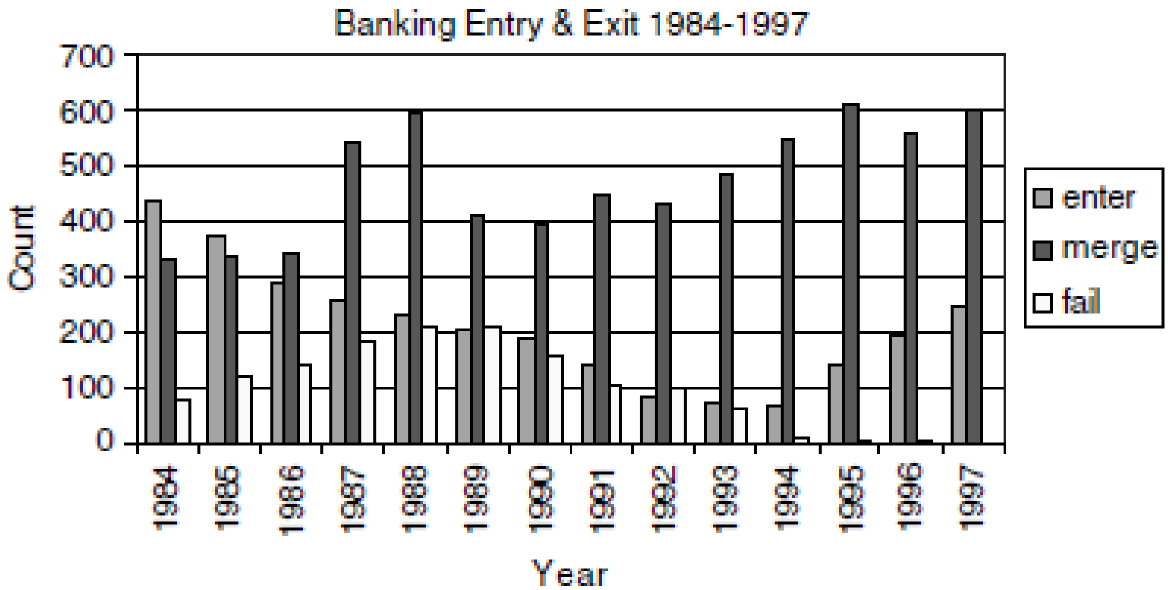

Figure 2. Patterns of consolidation in banking

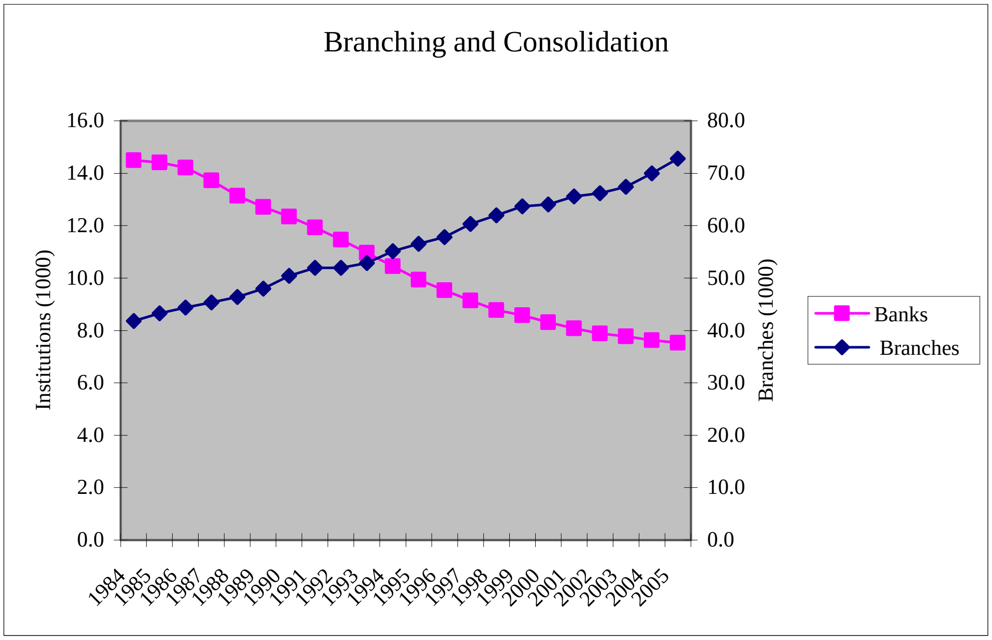

Figure 3. Histogram of periods until failure

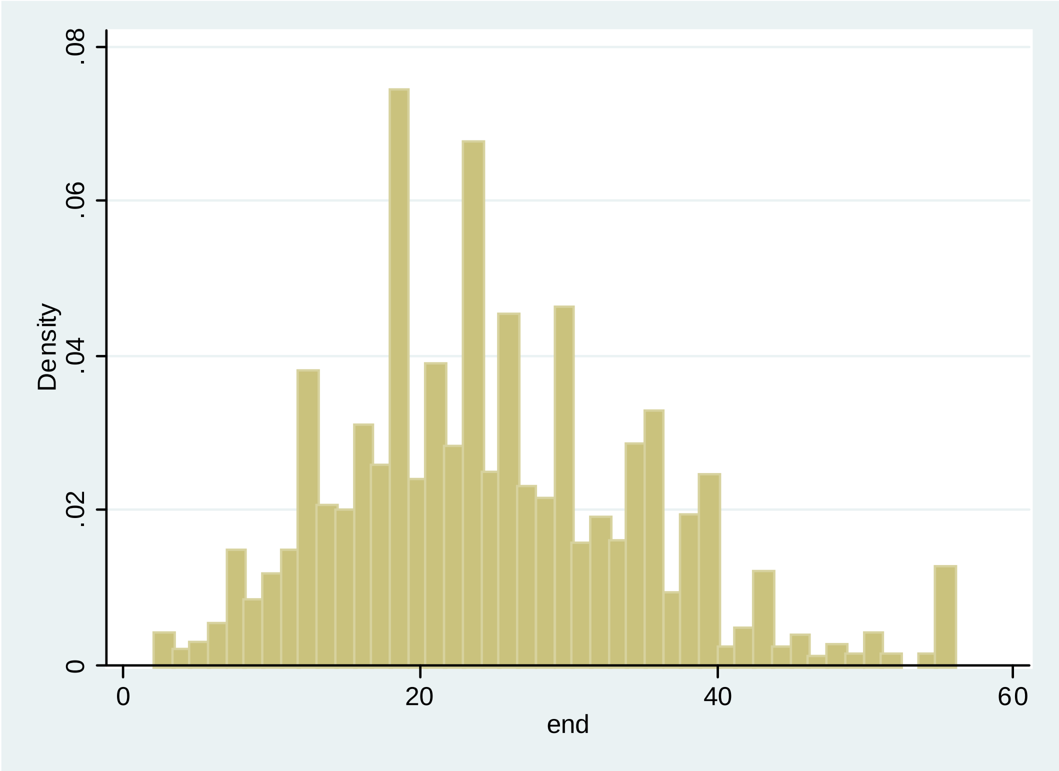

Figure 4. Mean quarterly profit history