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An encompassing model & test of the Evans-Jovanovic credit constraints hypothesis

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ABSTRACT

Using an unbalanced panel of some 36,500 French startup firms and 11,600 closures over the period 1994-2000 we test for a role of bank credit scoring in small business lending using an encompassing version (GEJ) of the seminal Evans-Jovanovic(1989) (EJ) model of credit constraints. In the GEJ model the bank's estimate of the probabilty of individual company survival (business *quality*) is allowed to figure in the startup credit decision, alongside collateral. On the French data EJ is rejected in favour of GEJ. Thus we conclude with EJ that there is evidence of startup credit constraints via bank lending rules, but that this imperfection is ameliorated by the bank's estimate of firm quality: better firms and entrepreneurs are more likely to get loans. Enrepreneurial human capital is also found (consistently with Cressy, 1996) to play a major role in the survival of startup businesses and hence in the chances of getting a loan. Consistent with other empirical work we also establish that startup loan refusal (an upper bound to rationing) affects only a small proportion (9%) of applicants. However, for those whose loan request is rejected, dynamics show that they have a *permanently higher* hazard of failure (by 50%-90%), relative to their funded counterparts. Credit constraints thus contribute to small business failure.

Key words: Entrepreneurship, startups, credit constraints, survival,France,panel data,hazard rate.

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1 Introduction

It might seem after 30 years of studies of credit constraints affecting young, small firms that the last word has been said on the matter. However, a cursory review of the literature shows that most studies of rationing are still not longitudinal in nature[i], thus ignoring the time dimension of the phenomenon, and even when they are, authors essentially bypass the role of firm or project quality in banking decisions. Evans and Jovanovic(1989) (EJ) identified theoretical criteria for credit constraints based on bank lending practices and proved (to their satisfaction) that they played a significant role in the US economy, concluding that virtually all (99%) start-ups were credit-constrained (had their loans downscaled). EJ argued that under credit constraints bank lending criteria would ensure a relationship between switching into or out of self-employment and the collateralisable assets of the business: capital constraints exist if and only if there is a positive correlation of assets and switching/survival.

Despite voices of dissent regarding their findings and the range of controls included (e.g. Aston, 1990; Cressy, 1996, 2006b), subsequent empirical studies tended to concur with their judgement: *on average,* small and young firms appear to be credit-constrained. (see e.g. Blanchflower and Oswald, 1990; Astebro and Bernhardt, 2005; Bridges and Guariglia,2008; Carpenter and Guariglia,2008). Although there has been widespread acceptance of the EJ criteria for rationing it is noteworthy that their theory makes several very restrictive assumptions about small business lending. It assumes firstly that banks are invariably making decisions about *viable* projects, projects with *positive* NPV; secondly, that the loan applicants operate under conditions of *certainty*[ii]*,* so there is *no need* for the bank to estimate the chances of business failure*;* and thirdly that loan refusal or downscaling itself cannot make a business fail*.*

These assumptions of course contradict the facts. In reality, projects' outcomes are invariably uncertain; financial risk is a major consideration in bank loan decisions; banks by and large reject requests from entrepreneurs to finance poor quality (negative NPV) projects; and rejection is usually predicated on credit-scoring models measuring the chances of repayment or bankruptcy. So any realistic study attempting to establish the existence of credit constraints (inefficient loan refusal or loan downscaling) must control for project quality (measured by the bank's estimate of the probability of bankruptcy) in addition to entrepreneurial assets representing collateral availability[iii]. The failure to allow for the role of firm quality in lending decisions has practical implications as it opens the door to erroneous policy-making. For example, recent large cross-country studies by the World Bank singularly fail to meet these criteria as firms' reporting having 'experienced difficulties' in raising finance is taken as indicating imperfections in the banking system and the need for government intervention (See Beck and Demirguc-Kunt,2006; Ayyagari,Beck andDemirguc-Kunt,2007; Beck, 2007)[iv].

In the present paper we address empirically the deficiencies in the EJ model. Using an unbalanced panel of some 36,500 French startup firms and 11,600 closures over the period 1994-2000 we test an encompassing version of EJ, we call it the Generalised EJ (GEJ) model. In the GEJ model the bank's estimate of the probabilty of individual company survival (business *quality*) is allowed to figure in the startup credit decision, alongside collateral. If only collateral is found to matter in the bank's decision, GEJ reduces to EJ, there are credit constraints and the bank cannot estimate the probability of failure. If quality and collateral matter, EJ is rejected in favour of GEJ, so that credit constraints are ameliorated by the bank's estimate of firm quality. If neither matter, the credit market is efficient.

Importantly, the empirics confirm the second hypothesis and are consistent with the GEJ model. Thus we conclude that there is evidence of startup credit constraints via bank lending rules, but that this imperfection is *ameliorated* by the bank's estimate of firm quality: better firms are more likely to get loans. Consistent with Cressy(1996) we also establish that startup loan refusal (an upper bound to startup rationing) affects only a small proportion (9%) of French startup applicants. However, for those whose loan request is rejected, our dynamics show that they have a *permanently higher* hazard of failure (by 50%-80%), relative to their funded counterparts. Thus credit rationing contributes to small business failure.

The rest of the paper is organised as follows. Section 2 provides a summary of the EJ model. Section 3 introduces the data and presents summary statistics on survival. Section 4 presents the encompassing model and estimates firm quality and the loan refusal probability. Section 5 provides estimates of the hazard of closure beyond startup. Section 6 reports robustness checks and section 7 summarises and concludes.

2 The Evans and Jovanovic (1989) model

Evans and Jovanovic (1989) (EJ) develop a theoretical model in which a profit-maximising entrepreneur chooses the amount of capital, including a bank loan, for his business, subject to bank lending rule which limits credit to a fixed proportion of his assets. The firm will then be credit constrained, they argue, if and only if there is a positive correlation of assets and probability of survival[v]. More assets increase lending available from the bank, thus increasing the marginal constrained firm's profits and hence the proportion of businesses surviving.

Consider the following maximisation problem for the entrepreneur.

$$Maximise_k \pi(k) = \theta f(k) - r[k - z] \quad (1)$$

Subject to

$$k - z \leq az, \quad a \in (0,1) \quad (2)$$

where

$k = capital\ in\ the\ business$

$\theta = entrepreneurial\ ability$

$r = 1 + rate\ of\ interest$

$z = collateralisable\ assets\ of\ the\ business$

$f(k) = a\ concave\ production\ function\ of\ capital;\ f' > 0, f'' < 0$

We derive the model's results mathematically in Appendix 1 and present the main findings here.

[Figure 1: Constrained and unconstrained entrepreneur in the EJ model]

In Figure 1 the unconstrained entrepreneur equates the marginal value product of capital with the interest rate at a level of capital k*, consisting of his own assets plus a bank loan, and generating profits π* in the process. The constrained entrepreneur by contrast has insufficient assets to reach k*, the desirable level of capital. He is constrained to choose $k = bz$ where b is determined by the bank. This means his marginal product of capital exceeds the interest rate and his profits are constrained to the smaller level $\pi(bz)$. If the bank's lending constraint is relaxed he will borrow more.

[Figure 2: Credit constraints and survival in the EJ model]

In Figure 2 we explore the effects of this constraint relaxation on the behaviour of the marginal entrepreneur. The probability of failure (business closure) is defined by the ability of the marginal entrepreneur, θ_0 whose profits are zero. This level of talent separates viable from nonviable businesses. Those with ability above θ_0 are viable and those with ability below are not (the latter will be in wage employment). If (and only if) the marginal entrepreneur is constrained will the proportion of businesses that are viable change with relaxation of the credit constraint. For the unconstrained entrepreneur a change in assets has no effect on the marginal entrepreneur's profits and hence her probability of failure, namely, $\Pr(\theta < \theta_0)$, since she already has the 'right' amount of capital and if the bank offers more she will turn the offer down. For the constrained entrepreneur, by contrast, more assets will reduce the chances of failure. From Figure 2, for a constrained entrepreneur with assets z_1 and marginal ability θ_1 the chances of business failure are A+B. As assets increase from z_1 to z_2 the ability of the marginal entrepreneur falls from from $\theta_1$to $\theta_2$and the probability of failure falls from A+B to B.

3 The generalised EJ model

In this model our measure of business quality has two components: entrepreneurial ability and skills. Entrepreneurial ability (say θ) is not observable but an interview with the owner-manager yields the bank a signal of this ability, s. We assume s is distributed in the population of applicants according to the known cdf, $\Gamma(s)$. The entrepreneur, given assets z, chooses a level of borrowing l and a level of skills q, to maximise profits. We shall assume in line with the literature (Fazari, Hubbard and Petersen, 1987) that the firm's cost of capital is convex in its borrowing amount. Thus the firm solves

$$Maximise_{l,q}\ \pi = f(k,q) - \frac{l^{1+r}}{1+r} - wq \tag{3}$$

where total capital, k, is the sum of the entrepreneur's assets and her borrowing:

$$k = z + l \tag{4}$$

r is a parameter and w is the cost of a unit of skills, q. We show in Appendix 2 that with a Cobb-Douglas production function and diminishing returns to scale, borrowing is then a decreasing function and skills an increasing function of the entrepreneur's assets z. Skills, are, by contrast with entrepreneurial ability, measurable and can be observed from a CV supplied in advance of the loan decision.

The bank deciding whether to make a loan of fixed amount I at a given interest rate r[vi] to an entrepreneur whose probability of success (i.e. of loan repayment) or 'quality' is p, where

$$p = p(s, q(z)),\ \ 0 < p(s,q) < 1, all\ s, p\ ;\ \ p_s,\ \ p_q > 0 \tag{5}$$

p is assumed increasing in s so that entrepreneurs with a higher signal of their ability s have a greater chance of repaying their loan. p is also increasing in skills q. The bank's return from lending is

$$p\big(s,q(z)\big)rl(z) + [1 - p(s,q(z))]z - cz,\ \ 0 < c < 1 \tag{6}$$

where z is the assets or collateral placed by the entrepreneur and c is fractional the unit cost of verifying ('perfecting') its value. Thus if the firm remains solvent with probability $p(s,q)$ the bank gets its loan back plus interest[vii]. If on the other hand the firm becomes bankrupt, with the complementary probability, the bank gets collateral z. If the bank doesn't lend it gets 1+the cost of funds, , times the loan amount, i.e.

$$\rho l(z) \tag{7}$$

The bank does not receive the signal of entrepreneurial ability s in advance and only finds out its value after an interview with the applicant. However, it will choose an optimal cutoff for this signal, $\hat{s}$, in advance, to facilitate an optimal choice once the signal is realised. At this point it chooses the maximum of the return to lending (19) and not lending (20). The optimal cutoff s^* then solves

$$maximise_{\hat{s}}\, V = Emax\{\, p\big(s, q(z)\big)rl(z) + \big[1 - p\big(s, q(z)\big)\big]z,\ \rho l(z)\}$$

$$= \int_0^{\hat{s}} \rho l d\Gamma(s) + \int_{\hat{s}}^1 \{p(s,q)rl + [1 - p(s,q)]z\} d\Gamma(s) \tag{8}$$

The First Order Condition (FOC) is

$$0 = V_{\hat{s}} = \rho l\widehat{\gamma} - \{\widehat{p}rl + (1 - \widehat{p})z\}\widehat{\gamma} \tag{9}$$

where $\hat{p} = p(\hat{s}, q)$ and $\hat{\gamma} = \Gamma'(\hat{s})$. Solving for p the optimal success probability we get:

$$p(\hat{s}, q) = \frac{\rho l - z}{rl - z} \tag{10}$$

This generates the lending cutoff of the form

$$\hat{s} = s^*(z, r, \rho, \mu) \tag{11}$$

where μ is a shift parameter in the human capital function $q(z; \mu)$ with $q_z > 0$ and an optimal probability of survival

$$\hat{p} = p^*(q, z, r, \rho, \mu) \tag{12}$$

We also get an expression for the probability of loan refusal :

$$\Pr(Refusal) = \Pr(s < s^*)$$

$$= \Gamma(s^*)$$

$$= \vartheta(p^*, q, z, r, \rho, \mu) \tag{13}$$

We show in Appendix 2 that the probability of rationing (loan refusal) is decreasing in human capital , survival and assets and that the probability of success is, under certain additional assumptions, increasing in collateral and human capital/survival and decreasing in the interest rate charged. Likewise the probabilities of success and loan refusal are decreasing in the interest rate.

[Figure 3: Credit constraints and survival in the GEJ model]

4 Data

4.1 Data Sources

The database used in this paper is the set of cohorts of the French SINE 94-1 database[viii]. This data is derived from a survey of French firms that had been set up or taken over in the first half of 1994 and which had survived for at least one month. Financial and survival data from follow-up surveys with the same firms was then added to the results of the initial survey until the year 2000. Surveys were conducted by the French National Institute of Statistical and Economic Studies and had a response rate of almost 100%. The cohorts consist of a stratified sample of some 36,500 firms involving some 11,600 closures over the 7-year period with entry mainly in 1994, 1995 and 1996[ix]. A range of firm, human and financial capital variables are recorded at startup and in the years following, together with failure information. The data is thus an unbalanced panel with time series for individual firms that vary between 1 and 7 years depending on if and when the firm closes. The definitions of variables used in the paper are presented in Table 1.

Rationing variable

The startup loan decision variable in our analysis, *refused_0*, is critical in our approach to startup credit rationing. It is equal to one if the firm applied for a bank loan *at startup* and was refused and is zero if it applied and was rejected. Clearly, a firm may not apply for a loan either because it doesn't need one, or because it expected to be refused if it did[x]. Likewise, an applicant firm may have a good (profitable) or bad (unprofitable) project and a rational, risk-neutral, perfectly - informed bank would reject the latter and accept the former. However, if credit constraints rule, even viable projects may be rejected. If this occurs systematically we have credit constraints[xi].

Survival/cessation variables

Two other critical variables in our analysis are the cessation dummy, *cess*, which is equal to one if the firm closed in the interval 1994-2000 and zero if not (censored observation)[xii]; and *cessnow*, which is equal to one in the year of closure (if the firm closes) and is zero elsewhere. A zero for this variable in the cutoff year for the dataset (the year 2000), however, indicates a censored observation, one for which the failure outcome is not known.

4.2 Descriptive statistics

The descriptive statistics for the firms in the first year of trading and subsequent years are shown in Table 2[xiii].

The businesses

From Panel B in Table 2, the typical startup business in this sample is an unincorporated business (*ltd=0*) rather than a limited company: just under half (46%) of the businesses were incorporated[xiv]. The start-ups were not large when measured by numbers of employees: from panel A, average annual full-time equivalent (FTE) employment (*employ*) in the cohort was between 1 and 2 people. This, however, is in line with evidence from other European countries (ENSR, 1996).

The entrepreneurs

From panel B the vast majority of entrepreneurs (75%) were male and had not been in business before (*novice=79%*). He entered business at around 37 years of age (*agef)*[xv]. He was not well-educated, typically having only the lowest level of the French Diploma (*maxdip*), whilst 20% had no Diploma at all (*nodip*). There is, as in the UK data, some evidence of unemployment-push into self-employment : around a half of entrepreneurs had previously been unemployed (*unemp, 50%*) somewhat larger than the UK figure of one third and 13% of entrepreneurs cited unemployment as their main reason for startup (*runemp*). 26% of entrepreneurs cited 'perception of an opportunity' (*opportunity*) as the primary motivator for startup whilst almost half found a 'taste' for entrepreneurship as the (dubious) driver. Although the educational level of the startup proprietors was low, individuals entering business were on average well-equipped in terms of work experience: around one third had over 10 years work experience (*durexp10plus*) in the same area as the startup.

The competition

Our measure of competition is the well-known Herfindahl (H) index of industrial concentration. The index is calculated for each industry j in year t, as the sum of the squared shares in turnover in that industry:

$$H_{jt} = \sum_{i=1}^{n_{jt}} s_{ijt}^2$$

where s_{ijt} = share of firm i in turnover of firms in industry j at year t and n_{jt} is the total number of firms in industry j at time t. The H index ranges in value between $1/n_{jt}$ and 1. $H_{jt} = 1/n_{jt}$ is associated at one extreme with an industry composed of identical firms ($s_{ijt} = s_{jt}, i = 1,2 \ldots., n_{jt}$) which tends to perfect competition as $n_{jt} \longrightarrow \infty$, and at the other extreme with monopoly, when the firm and industry coincide and $n_{jt} = 1$.

[Table 1: Variable definitions]

with n_{jt} equal-sized firms and as n_{jt} goes to infinity we have perfect competition ($H_{jt} = 0$). At the other extreme we have $H_{jt} = 1$ associated with monopoly (one firm with 100% of the market). The table shows that most firms faced a relatively high level of competition (*herf*) in their chosen industry in the year of entry with overall average n about one hundred companies (100=1/0.01).

The finances

As regards financing, from panel B only half of businesses requested a loan (*req_0*) at startup. Of the businesses that did so, only 9% were refused (*ref_0*). Thus credit rationing at startup (for which this figure provides an upper bound) is not a widespread phenomenon amongst French businesses in the period, confirming the Aston(1990) and Cressy(1996) findings for the UK[xvi].

From panel A the average startup loan (including zeros for those not requesting/taking a loan), used typically for fixed investment, was French Francs (subsequently F) 21.6k for short term loans or loans less than 2 years (*newbank2m*) and F58.1k for long term loans, loans greater than 2 years (*newbank2p*). By contrast, bank Overdrafts or Lines of Credit from the bank (*ODnew*), used to smooth short-term cash flows from sales and purchases, averaged at F10.6k per annum in the first year. Looking at the costs of borrowing, long and short-term nominal interest rates in France (*ltintrat, stintrat*) during the period averaged at just over 7% and 6% respectively per annum.

From Panel A, 40% of a firm's assets were available as collateral (*collrat*)[xvii] at startup. The typical capitalisation (*ga*) of a French business startup was F633k with a turnover of F1068k per annum.

Moving now to financial risk, the average startup debt ratio (debt/TA or *debtrat*) at 78% indicates that the vast majority of the firm's assets were financed by debt rather than equity and therefore presented a significant financial risk to the average startup. Average annual profit (*profit*) in the cohort was some F1020k[xviii] at startup, but some firms recorded big losses and others much larger profits. Government financial support (*govaid*) was quite widespread for start-ups with over one third (39%) of firms receiving some kind of support at this stage.

[Table 2: Year one descriptive statistics]

4.3 Differences between refused and offered firms at startup

Table 3 below shows that most of the theory variables at startup (first year of trading) differ significantly between refused and offered companies. Refused firms tend to be more closure-prone, have less collateral, are smaller (on several measures, real and financial), less profitable, have owners that are less financially committed, less relevantly experienced and less likely to have identified a gap in the market and were more likely to have been pushed into rather than to have chosen self-employment.

[Table 3: Mean differences between applicants for loans refused and those offered in startup year]

4.4 Correlations and condition number

The correlation matrix for the time-varying covariates is presented in an Appendix to the paper available from the authors. It shows 'large' correlations (>50%) between the three measures of firm size*: ga, employ* and *turn* and between *gdpgrowth* and *ltintrat*. There are also significant correlations between the financial variables. However, the condition indices and variance proportions for each variable shows that none of the correlations in this matrix are indicative of 'degrading' collinearity as defined by Belsley, Kuh and Welsch(1980). There is thus no need to run separate regressions for subsets of the variables despite some of the correlations amongst a minority of regressors being rather high.

5 Credit rationing: theory and estimates

5.1 Definition of project/firm quality

We define project quality as the probability of survival during the period 1994-2000*, conditional only on information available to the bank at the point where the firm starts trading*. We assume (on good evidence) that during this period the bank manager has a large sample of startups on which to base his or her estimates of the chances of a business failing. However, little beyond startup information, other than that on account closure, was likely to be available to bank managers in this era. Certainly, they would not have been able to calculate a hazard rate of failure requiring data well beyond the startup point[xix].

5.2 Definition of rationing

In a perfectly functioning credit market the bank lends to firms on the basis of the probability that the loan will be repaid, the interest rate it charges and the alternative return on its funds. Thus we assume in the GEJ model and along with EJ, that if the bank uses collateral as a basis for lending, even if this is *in addition* to estimates of firm quality, that credit constraints exist and there is inefficiency in the lending process. In the extreme case examined empirically below, credit constraints imply that the loan is refused altogether. This is credit rationing if the project is 'good'.

5.3 Estimation: the encompassing model

We saw that the EJ model examines the probability of failure in the population only and assume that at the firm level, there is no uncertainty: a firm fails or succeeds with probability one conditional on its profits. The EJ model also implies credit constraints if and only if there is a positive correlation of business survival (success) and assets. We have generalised this model in several ways and this is reflected in the empirical specification. Firstly, we have allowed for uncertain failure at the individual firm level. Secondly, we have allowed that the bank's decision on whether to lend may include this probability as well as collateral. Thirdly, we have allowed that loan refusal may impact the probability of failure. Thus, the *Generalised EJ model (GEJ)* has two equations, one for the probability of survival and one for the probability of loan refusal. We expect, following EJ and Bates(1990), that the financial variables are endogenous, in other words that they are functions of the exogenous variables. However, we shall test for this in the regressions to follow.

In GEJ the startup lending decision (equation 25) gives the bank's judgement of the unobservable loan performance of the business, $ref\_0_i^*$, as a function of the quality of the business and the collateral available for the loan[xx]:

$$ref\_0_i^* = \gamma_0 + \gamma_1 surv_{0i} + \gamma_2 collrat_{0i} + \gamma_3 controls_i + u_i \tag{26}$$

where $surv_{0i}$ is the bank's measure of the ith business' quality, $collrat_{0i}$ is the collateral available to the firm and u_i is a Normally distributed white noise error term. Our model indicates that various controls should also be added, namely base short and long term interest rates, GDP growth, and industry dummies.

Both variables for this regression are measured at startup as indicated by the 0 subscript. We do not observe $ref\_0_i^*$ but rather the binary counterpart, ref_0_i , defined by the theory (equation 30) and with empirical implementation

$$ref\_0_i \;= 1\; iff\; ref\_0_i^* < 0 \tag{27}$$

where $ref\_0 = 1$ refers to a refusal of the loan; $ref\_0 = 0$ to it being offered. The original EJ model then drops out as a special case. We thus estimate the probability of being refused a loan as defined in equations 31 and 32 above.

Table 4 shows the possible values under the four different outcomes. Each row presents one of the four hypotheses, H1-H4. We maintain that hypothesis H4: the GEJ model with firm quality and rationing, best describes the data. This implies that γ_1 and γ_2 are both negative. The EJ model (H2) by contrast implies that γ_2 is negative and γ_1 is zero.

[Table 4: Encompassing model: hypotheses]

However, we also have another maintained hypothesis[xxi]:

H5: Startup loan refusal ($ref\_0 = 0$*) increases the chances of failure.*

On the basis of the GEJ model above (specifically, theory equation 23) we formulate the following regression

$$surv_i^* = \pi_0 + \pi_1 ref\_0_i + \pi_2 collrat_i + \sum \pi_{3j} HC_{0ij} + \sum \pi_{4j} Ind_{ij} + \pi_5 herf\_0_i + v_i \qquad (28)$$

This has observable counterpart

$$surv_i \;\; = 1 \; iff \; surv_i^* > 0 \qquad (29)$$ [xxii]

Here for firm/entrepreneur i, surv is the probability of survival ('success'), *collrat* is a measure of available collateral, *HC* is a vector of human capital variables, *Ind* a vector of industry dummies, and *herf* is the Herfindahl index. The four main hypotheses corresponding to the different states of the world are shown in Table 2. The additional Hypothesis 5 corresponds to testing whether $\pi_1 < 0$.

To allow for the endogeneity of loan refusal and survival we estimate the two relationships 28 and 29 simultaneously using 3SLS and also estimate a single equation IV probit for *ref_0* with potentially endogenous *surv* as a robustness test on equation 29.

5.4 Startup estimates of quality and loan refusal

It is easily verified that the system of equations defined by 26 and 28 is identified by the Rank condition. Due to the likelihood of heteroskedasticity, we chose 3SLS, with its general variancecovariance matrix, as the method of estimation. The 3SLS estimates are reported as Model 1 of Table 5.

The model is highly significant overall (p>chi2=.000 for both equations), suggesting that we have the right variables to explain credit refusal. Note also that *surv* and *collrat_0* are both negative and highly significant so that alongside security the bank takes into consideration the firm's quality in making its startup loan decision, a finding consistent with GEJ (H4) and inconsistent with EJ (H2)[xxiii]. Furthermore, the loan refusal variable, *ref_0,* is of the 'right' negative sign for H5 and is statistically significant (p=.03) in the *succ* structural equation, indicating that business quality (survival probability) is in fact reduced if firm is refused a startup loan[xxiv], consistent with H5.

For robustness, we first estimate the loan refusal probability with a single equation method, namely, IV Probit. This allows that quality (*surv*) may be endogenous and we instrument *surv* with the full set of exogenous variables. The results (Model 2) are in qualitative terms essentially the same as for Model 1 and the Wald exogeneity Chi-square indicates that *surv* is indeed endogenous in the *ref_0* equation[xxv].

6 Hazard of closure

In the last section we examined credit refusal and firm quality based only on information available to the bank *at startup* and tested the GEJ against EJ to establish credit rationing based on bank lending criteria. We concluded that GEJ is a better model to describe startup loan decisions. In this section we look forward in time to estimate the chances of a firm closing in year t *after startup*, given that it has not closed prior to t. This *hazard* of failure is now a function of variables determined at startup *and subsequently*. Whilst this kind of data is unlikely to be available to the bank at the startup stage in the period of the study, estimating the function will help to answer the question of how *persistent* the effects of initial values are in subsequent survival outcomes and in particular how persistent are the effects of initial credit rationing. Unlike the 3SLS and IV probit at startup, then, which were models conditioned *only* on the initial values of the variables, the hazard rate will also in general be a function of *current and/or lagged values* of the variables. We now drop the assumption that financial variables are chosen by the entrepreneur as a function of exogenous HC, industry and macro factors. To check for robustness to endogeneity we also estimate a model with lagged regressors. We shall see that the results are essentially the same.

[Table 5: Estimates of credit refusal and firm quality at startup]

6.1 Survival function

Our time variable in the hazard rate empirics is so-called 'analysis time' (see Cleves, Guttierez and Marchenko, 2010) and runs from 1,2 …6. There are three main entry cohorts, those of 1994, 1995 and 1996, with rather small cohorts in later years.[xxvi] Analysis time thus recodes these dates to 'merge' the cohorts, so standardizing across the time dimension.

From Table 6 we can see that in the first year 36,535 firms started trading or were 'at risk' of closure. 2,287 of these or about 6% of the cohort(s) closed between trading years 1 and 2 whilst 1607 were censored. Since censored observations (firms) reduce the risk set (numbers left at risk of closure in any give year), these must be subtracted, along with the closures, from the initial 36,535 firms, leaving 32,641 firms at risk at the beginning of trading year 2. A further 2,504 firms closed by the end of trading year 2,which along with 669 firms censored, left a total of 29,468 firms at the beginning of trading year 3. Continuing this process until the beginning of year 6, we are left with only 15,805 firms at risk.

The survival function associated with this process is shown in the last column of the table[xxvii]. The survival probability for any year t is the proportion of firms that survive *beyond* t given that they have survived *up to* year t. To get the survivor probability for the first year we subtract closures in year 1 from the stock at the beginning of the year and express this as a proportion of that stock. This gives a survival rate for the first year of 93.74%. We do the same thing for year 2 and get 92.33%. However, to get the survivor probability for year 2 we need to then multiply this by the first year rate to give 86.55%. This is the probability of surviving beyond year 2 *given* that the firm has survived beyond year 1. This process of attrition continues until at the end of year 6. At this point 36% of the original stock had died giving a total survival rate of 64%.

[Table 6: Survival and closure of the startups over time]

Figure 4 below plots the Kaplan-Meier (K-M) failure function which reports (1 *minus* the survival rates) of Table 6. It is S-shaped in analysis time or years trading.

6.2 Hazard regression strategy

The hazard rate at time t for a company, h(t) , is defined as the probability that the business will close in the next year given that it has survived to date. Analytically (in continuous time) we have

$$h(t) = f(t)/[1 - F(t)] \tag{30}$$

where f(t) and F(t) are the density and cumulative density of failure time respectively. This model

[Figure 4: Kapan-Meier failure function]

can be fully parameterised in many ways (see Cleves et al, 2010, for details). The Cox proportional hazard model however is semi-parametric and takes the form

$$h(t) = h_0(t)\exp\left(\beta_1 x_1 + \cdots + \beta_k x_k\right) \tag{31}$$

Here $h_0(t)$ is the Cox baseline hazard function, the x's are explanatory variables (which may vary over time)[xxviii] and the betas are a set of fixed coefficients. The hazard function in the Cox model is not prespecified in the estimation and this lack of specification makes the model very general in form. We estimate several versions of this model which are reported in Table 7.

Model 1: Initial values only

To incorporate the effects of initial values of key time-varying covariates and of variables only available at startup (such as HC and credit rationing), we estimate Model 1 with a linear specification.

Model 2: Current values only

Model 2 examines the effect of the current values only (i.e. values of the time-varying variables measured at time t) on the hazard of closure using a linear specification.

Model 3: Lagged values

Since it is arguable that some of the current values of the variables (e.g. size, profit) may be endogenous to closure (size and profits of a firm may decline as closure approaches) in Model 3 we estimate the model using lagged values of the time-varying regressors, again with a linear specification.

Model 4: Quadratic forms

To address the issue of model specification, Model 4 fits initial and current values with a quadratic specification.

Model 5: Quadratic initial values with time-varying covariates

To allow that the effects of initial values and other time-invariant variables on the closure hazard may vary over time, in model 5 we introduce into the Cox model time-varying components of the form $z.g(t), g'(t) < 0$ where z is a vector of time-invariant covariates and g(t) is the chosen function of t, the time at risk (time trading since startup)[xxix]. This allows for a declining effect of initial values (credit rationing, HC etc) over time whilst retaining proportionality of the hazards.

6.3 Hazard estimates

Table 7 reveals that financial and human capital, firm size and capitalisation factors play a major role in determining the hazard of closure. Bank lending (short and long term) subsequent to startup (*newbank2m, newbank2p*) has little effect on closure in models 1-3 and these two variables are dropped in later models. Capital expenditure by contrast (probably financed by retained profits) operates to reduce the hazard of closure in all models 2-6. These effects operate both at the startup stage (models 1,4-6) and subsequently (models 1,2,4-6). They play a similar role in the lagged model (model 3) introduced, as mentioned, to circumvent the issue of endogeneity.[xxx] The better-specified models (quadratics, models 4-6) show a concave relationship of the covariates to the hazard of closure.

On the human capital side we find that the hazard of closure is ameliorated by the entrepreneur's being motivated to start up by finding a gap in the market (*opportunity*), by his being more mature (*agef*) and by his acquiring long prior work experience in the area of the startup (*durexp10plus*). By contrast, the hazard of closure is increasing in prior unemployment , especially if this is cited as the main reason for starting up (*unemp* and *runemp* respectively). Finally, education and business experience have no effect on the hazard of closure (*nodip* and *novice*).[xxxi] [xxxii]

Examining financial capital factors, the chances of closing in the next year are ameliorated by availability of collateral (*collrat*), better capitalisation (*ga*), lower financial risk (*debtrat*), greater retained profits (*equity*), greater capital investment (*capex*) and choice of limited liability structure(*ltd*). The effect of financial risk mirrors the theoretical literature and some recent findings from European small businesses. The role of retained profits is consistent with capital market imperfections widely discussed in the literature. The capital investment decision (*capex*) and its effect in reducing the hazard of closure is also likely to be associated with retained profits since both the bank loan variables (*newbank2m* and *newbank2p*) are quite insignificant in all models[xxxiii]. Finally, the collateral effect (demonstrated in unreported regressions) mediates through the availability of long term loans, even though such loans do not figure as a significant separate regressor[xxxiv].

Competition effects represented by the Herfindahl index (*herf*) indicate, interestingly, that greater product market competition is associated with a greater chance of closing in the next period. This is particularly strong at the startup stage (*herf_0*) as predicted in the theoretical literature and supported by other empirical work[xxxv].

As regards the level of aggregate demand, in all models except model 2 (current values only) economic growth, as expected, reduces the chances of closure.

The effects identified in models 1-4 of Table 7 are so far, by assumption, *permanent*: they affect the firm's hazard rate of closure for all years from birth to death. The modelling procedure used so far only allows for a step change in the hazard in response to a change in the initial values. We can test this assumption by modelling time-interactions with initial values of the key variables as discussed above. The time function we use is exponential decay[xxxvi].

Economic effects

Model 5 of Table 7 allows for time-varying covariates, TVCs. Our time function for decay assumes a half-life of 2 years or an instantaneous rate of decay of 35%. This implies that the initial shift brought about by a variable (at $t = 0$) is $\beta_1 + \gamma_1$. At $t = 1$ this decays to $\beta_1 + \gamma_1(.70)$ at t=1 and to $\beta_1 + \gamma_1(.50)$ at t=2, and so on. If β_1 or γ_1 is insignificant we drop it in the calculations. Thus, if we consider *ref_0*, which has $\gamma_1 = 0$, there is at $t = 0$ a *permanent* upward shift of the hazard of failure by 91%. But for *unemp* the effects are merely temporary with an initial rise in the hazard of failure of 62% as the entrepreneur (hypothetically) switches from no previous unemployment to having previously been unemployed. This is followed in year 1 by a 100(.62)(.70)=43% difference, and in year 2 by a 100(.62)(.50)=31% difference, and so on. Thus the effects of being unemployed before startup on the subsequent hazard of business closure decline quite significantly over time, falling to only 1% in year 5. Nonetheless, the effects are still surprisingly long-lasting.

For an analysis of the effects of changes in the continuous variables, calculations assume a 10% increase in the focal variable at the sample mean. For these variables we can also calculate elasticities. The largest in absolute value of these elasticities is that for *agef*, with an elasticity of 1.8. So a 10% increase in the age of entrepreneur at the mean results in a 2% reduction in the hazard of failure relative to that at the mean.

6.4 Hazard function

Despite the fact that the baseline hazard function in the Cox model is not specified its form can be determined from the data. (See Cleves et al, 2010, for details). Figure 5 below shows the estimated baseline hazard function for model 4[xxxvii] of Table 7. It is consistent with the theory of Cressy(2006) that argues for an initial peak followed by a low long-run failure rate, though the definition of the long run in that paper is 'as t tends to infinity', so that we cannot pretend able to observe long run behaviour of the hazard rate in this dataset .

The hazard function of Figure 5 peaks at 5.5% just after 4 years into trading and then declines to about 5.25% in year 5.[xxxviii] Figure 6 shows how the hazard function differs between refused and non-refused firms. The curves are almost exactly parallel and, as stated earlier, the ratio of the heights of the two curves is about 1.5:1, indicating that refusal is associated with a permanent 50% increase in the hazard of closure[xxxix].

[Table 7: Estimates of the Cox hazard of closure]

[Figure 5: Cox hazard function (Model 4)]

[Figure 6: Hazard function shifts under rationing]

6.5 Robustness checks

In Appendix 2 to the paper we report graphical robustness checks on the Cox model's assumption, namely that hazards are proportional. The test examines the hazard function for different values of two of the binary variables, namely*, ref_0* and *runemp*. (The same tests were performed on other the binary variables in the dataset; this is merely illustrative). For the PH assumption to hold we need the curves to be parallel in each case. We note that in both charts the curves are indeed approximately parallel, indicating satisfaction of the PH assumption for these variables.

We also ran parametric hazard regressions using a variety of distributions. The most satisfactory of these were the Weibull and the Gompertz distributions, both of which produced coefficient signs are quite similar but with differences in significance, to those of the Cox model 4. However, their estimated hazard functions increase monotonically throughout the time interval, an implausible finding given what we know from other studies. Results are available from the authors on request.

7 Summary and Conclusions

On an unbalanced panel of some 36,500 French startup firms and 11,600 closures over the period 1994-2000 we tested an encompassing version (GEJ) of the Evans-Jovanovic(1989) (EJ) model of credit constraints, focusing on the special case of credit rationing. In the GEJ model the bank's estimate of the probabilty of individual company survival, based only on startup data, was allowed to figure in the startup credit decision, alongside collateral identified by EJ. We called this probability a measure of business *quality*. Interestingly, the empirics showed that not only can the bank plausibly estimate individual startup firm quality; it was also found to play a highly signficant role in the credit decision alongside collateral. Thus we concluded along with EJ that there is evidence of a credit market imperfection (lending not based on economic criteria), and that credit constraints in the Evans and Jovanovic(1989) sense, exist. However, the role of firm quality in lending means that their effects may be ameliorated: higher quality firms are more likely to get loans. Consistent with Cressy(1996) we also established that startup loan refusal affects only 9% of applicant companies and importantly *is less likely for high quality (specifically high human capital) businesses*. The dynamics of startup credit refusal showed, moreover, that it has significant long-term consquences: firms denied a startup loan have a *permanently* higher hazard of failure (by 50%-80%) over the next six years, relative to their funded counterparts.

Whilst the effects of credit rationing on the typical startup could in principle be ameliorated, in particular by the availability of collateral for borrowing, at firm level collateral rates vary little over time trading, making the building up of collateral an ineffective solution for most rationed businesses wishing to grow. Surviving firms that lacked capital because of their inability to offer security still suffered the same problem seven years down the line and were still as failure-prone. Of course there were countervailing factors, and firms with high profits are able to circumvent this constraint by building up equity to finance investment projects, but this is an option available only to a minority of firms.

In conclusion, the finding that the effects of rationing are persistent and are ameliorated by collateral availability is, we believe, ample evidence for the continuing role of government or mutual small firm loan guarantee schemes in mitigating credit market imperfections facing growth-oriented startups.

References

Abdesselam, R., Bonnet, J., and Le Pape, N., 2004, An explanation of the life span of new French firms, *Small Business Economics 23:* 237-254

Amemiya, T., 1978, The estimation of a simultaneous equation generalized probit model, *Econometrica 46,* 1193-1205

Astebro, T. and Bernhardt, I, 2005, The winner's curse of human capital, *Small Business Economics 24*, 63-78

Aston Business School, 1990, *Constraints on the Growth of Small Firms,* Department of Trade and Industry, UK

Audretsch, D. B., & Mahmood, T. (1995). New firm survival: New results using a hazard function. *Review of Economics & Statistics, 77*(1), 97.

Ayyagari, M., Beck, T., & Demirguc-Kunt, A. (2007). Small and Medium Enterprises Across the Globe. *The Small Business Economy, 29*(4), 415-434.

Bates, T., 1990, Entrepreneur human capital inputs and small business longevity*, Review of Economics and Statistics 72(4)*, 551-559

Beck, T, 2007, Financing constraints of SMEs in developing countries: Evidence, determinants and solutions, *Journal of international money and finance* 31(2), 401

Beck, T., Demirguc-Kunt, A., 2006, Small and medium-size enterprises: Access to finance as a growth constraint, *Journal of Banking & Finance 30,* 2931–2943

Belsley, D.A., Kuh, E., Welsch, R.E., 1980, *Regression Diagnostics: Identifying Influential Data and Sources of Collinearity,* John Wiley

Blanchflower, D., and Oswald, A.,1990, What makes an entrepreneur?, Manuscript, London: London School of Economics

Bridges, S., and Guariglia, A., 2008, Financial constraints, global engagement and firm survival in the United Kingdom: Evidence from micro data*, Scottish Journal of Policitcal Economy 55(4), September*, 444-464

Brüderl, J., Preisendörfer, P., & Ziegler, R. (1992). Survival Chances of Newly Founded Business Organizations. *American Sociological Review, 57*(2), 227-242.

Carpenter, R.E., and Guariglia, A., Cash flow, investment and investment opportunities: New tests using UK panel data*, Journal of Banking and Finance 32,* 1894-1906

Cleves, M., Gutierrez, R.G., Gould, W., Marchenko, Y.V.,2010, *An Introduction to Survival Analysis Using Stata, 3rd Edn,* STATA Press.

Cosh, A., Cumming, D. and Hughes, A., 2009, Outside Enterpreneurial Capital, *The Economic Journal 119, October,* 1494-1533

Cressy, R.,1996, Are business startups debt-rationed?, *Economic Journal, 106*(438), 1253-1270.

Cressy, R. , 2002, "Funding gaps: A symposium", *The Economic Journal* (February), 1-20

Cressy, R. , 2006a, Why do Most Firms Die Young?, *Small Business Economics, 26*(2), 103-116.

Cressy, R., 2006b, *Economics Letters [risk aversion]*

Cressy, R., and Storey, D.J., 1994, *New firms and their bank*, National Westminster Bank of Great Britain, reprinted in *Rassegna Economica* LXII(1), 1998, journal of the Banco di Napoli, 213-239

Evans, D. S., and Jovanovic, B. (1989). An Estimated Model of Entrepreneurial Choice under Liquidity Constraints. *Journal of Political Economy, 97*(4), 808.

Fazzari, S.M., Hubbard, R.G. and Petersen, B.C., 1988, Financing constraints and corporate investment, *Brookings Papers on Economic Activity, 1988(1),* 141-195

Geroski, P. A., Mata, J., & Portugal, P. (2010). Founding conditions and the survival of new firms. *Strategic Management Journal, 31*(5), 510-529.

Han, L., Fraser, S., and Storey, D.J., 2009, Are good or bad borrowers discouraged from applying for loans? Evidence from US small business credit markets, *Journal of Banking and Finance 33*, 415-424

Holtz-Eakin, D.,Joulfaian, D., and Rosen, H.S.,1994, Sticking it out: Entrepreneurial survival and liquidity constraints*, Journal of Political Economy 102(1):*53-75

IFC, 2010, Scaling-Up SME Access to Financial Services in the Developing World.Washington DC.

Jovanovic, B., 1982, Selection and the Evolution of Industry. *Econometrica*, 50, 649-670.

Kon, Y., and Storey, D.J.,2003, A theory of discouraged borrowers, *Small Business Economics 21*, 37-49

Mata, J., & Portugal, P., 1994, Life Duration Of New Firms. *Journal of Industrial Economics, 42*(3), 227.

Mata, J., & Portugal, P. , 2002, The Survival of New Domestic and Foreign-Owned Firms. *Strategic Management Journal, 23*(4), 323.

Mata, J., Portugal, P., & Guimaraes, P. (1995). The Survival of New Plants: Start-Up Conditions and Post-Entry Evolution. *International Journal of Industrial Organization, 13*(4), 459.

Stiglitz, J. & Weiss, A (1981). Credit rationing in markets with imperfect information. *American Economic Review,* 71, 393-410.

Taylor, M.P., 1999, Survival of the fittest? An analysis of self-employment duration in Britain, *The Economic Journal 109(454), Conference Papers, March*,CC140-155

Welch, B.L.,1947, The generalisation of 'student's' problem when several different population variances are involved, *Biometrica 34:* 28-35

Tables, Figures and Charts

Figure 1

Constrained and unconstrained entrepreneur in the EJ model

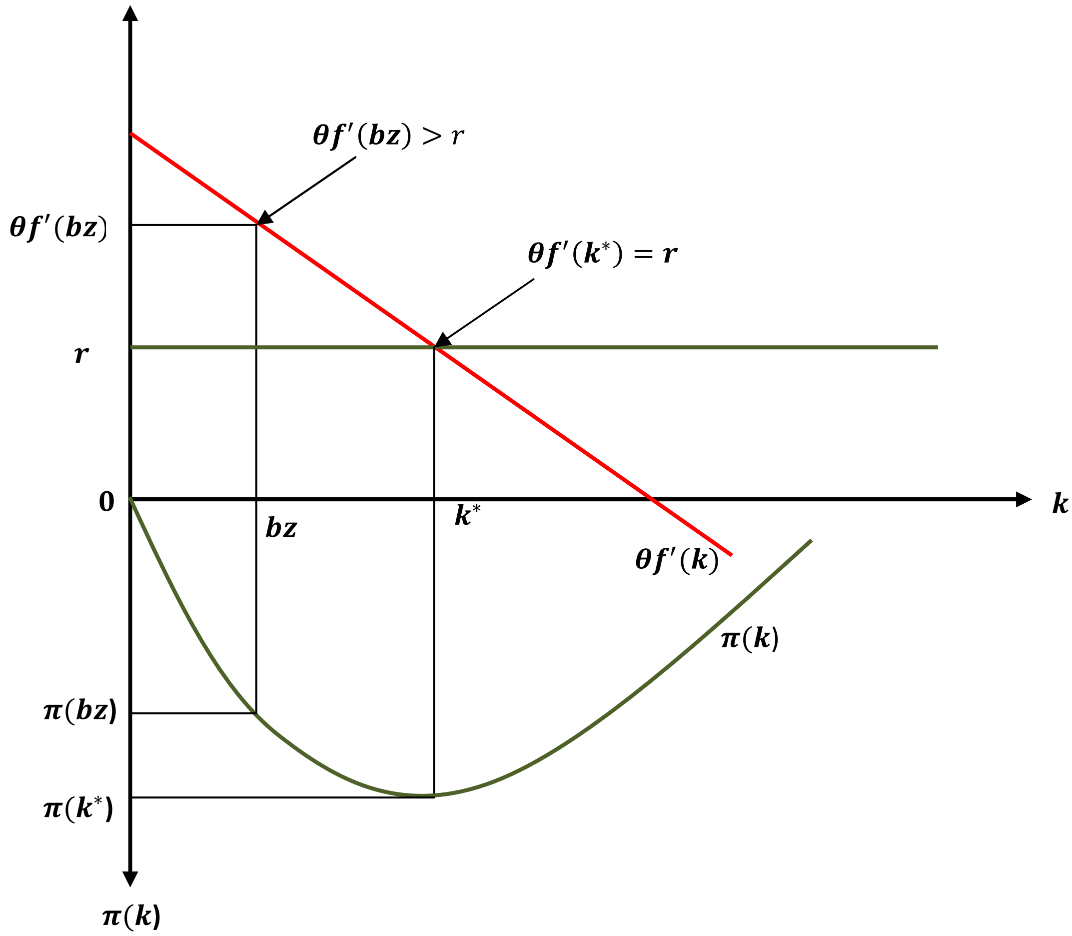


Figure 2: Credit-constraints and survival in the EJ model

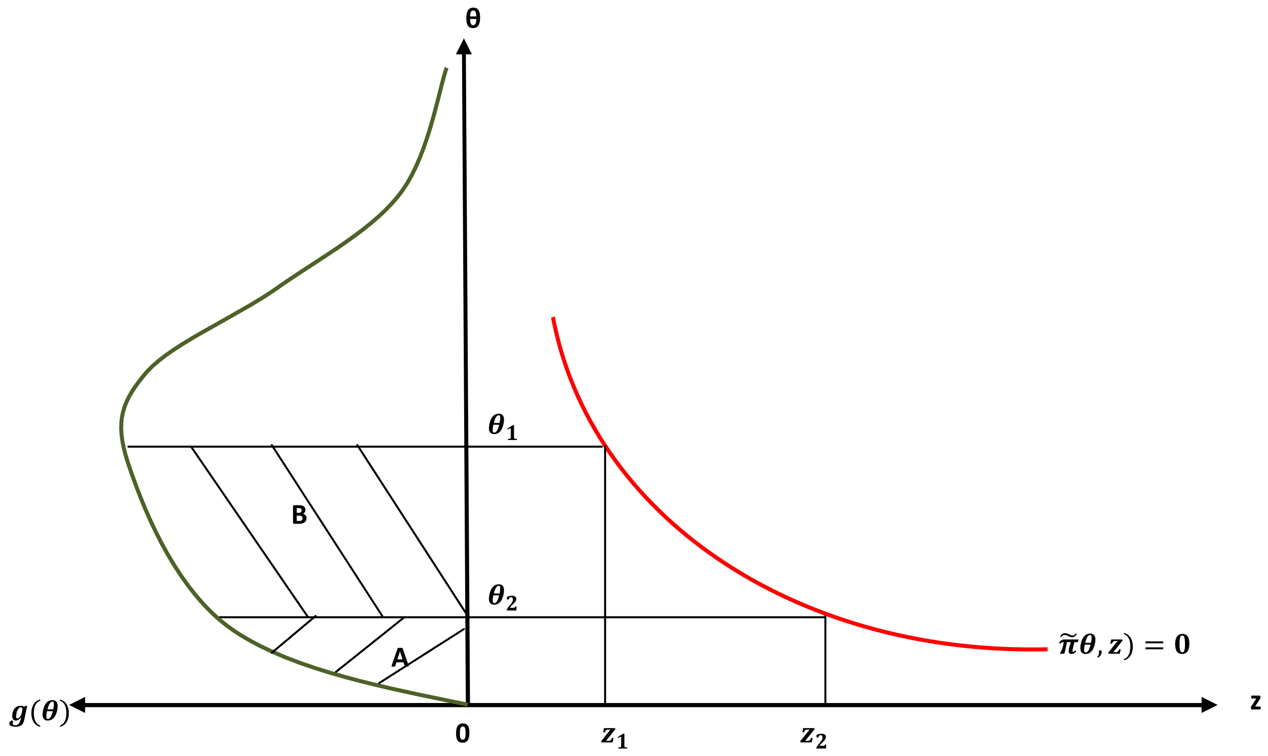


Figure 3: Credit constraints and survival in the GEJ model

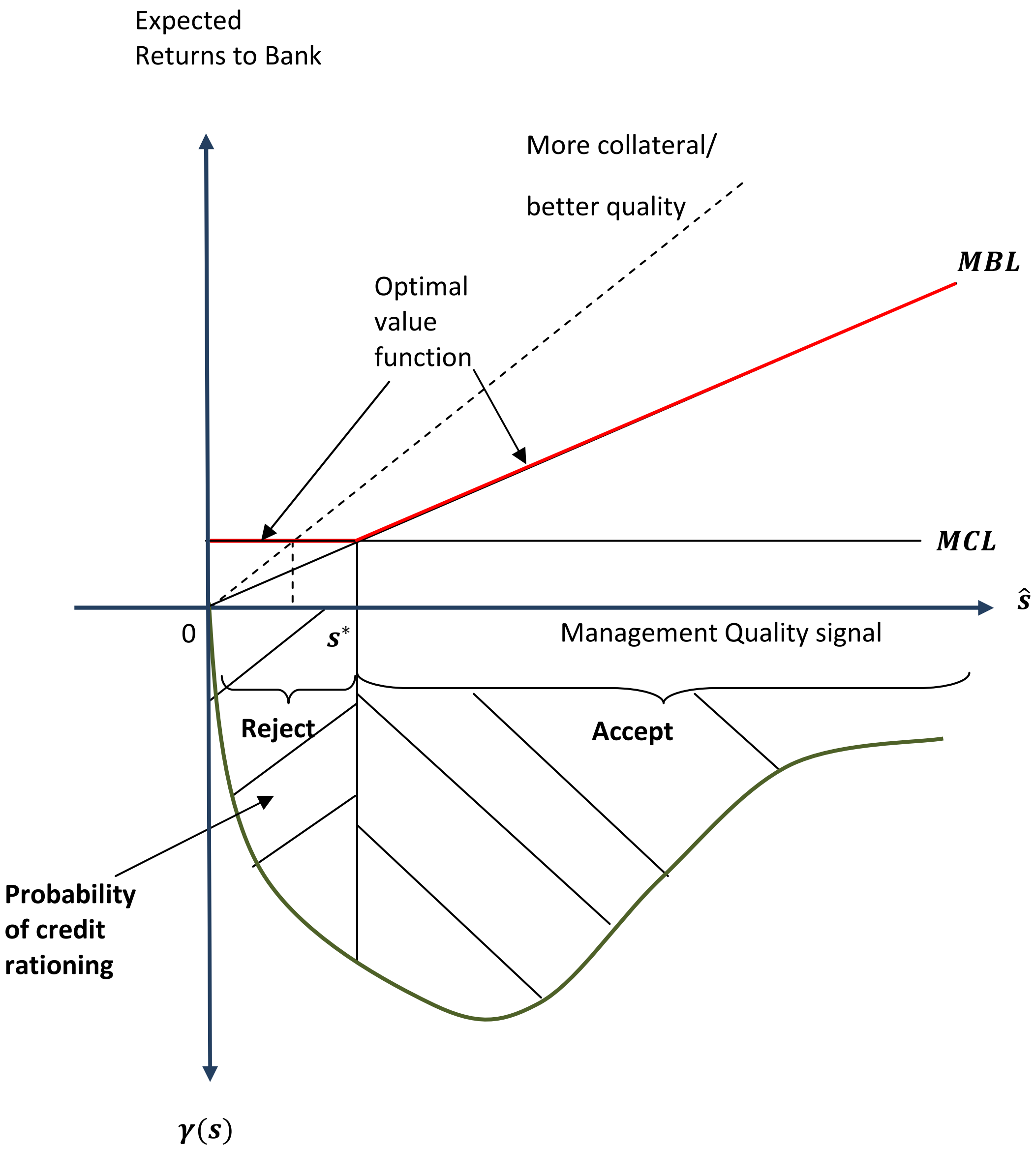


Figure 4: Kapan-Meier failure function

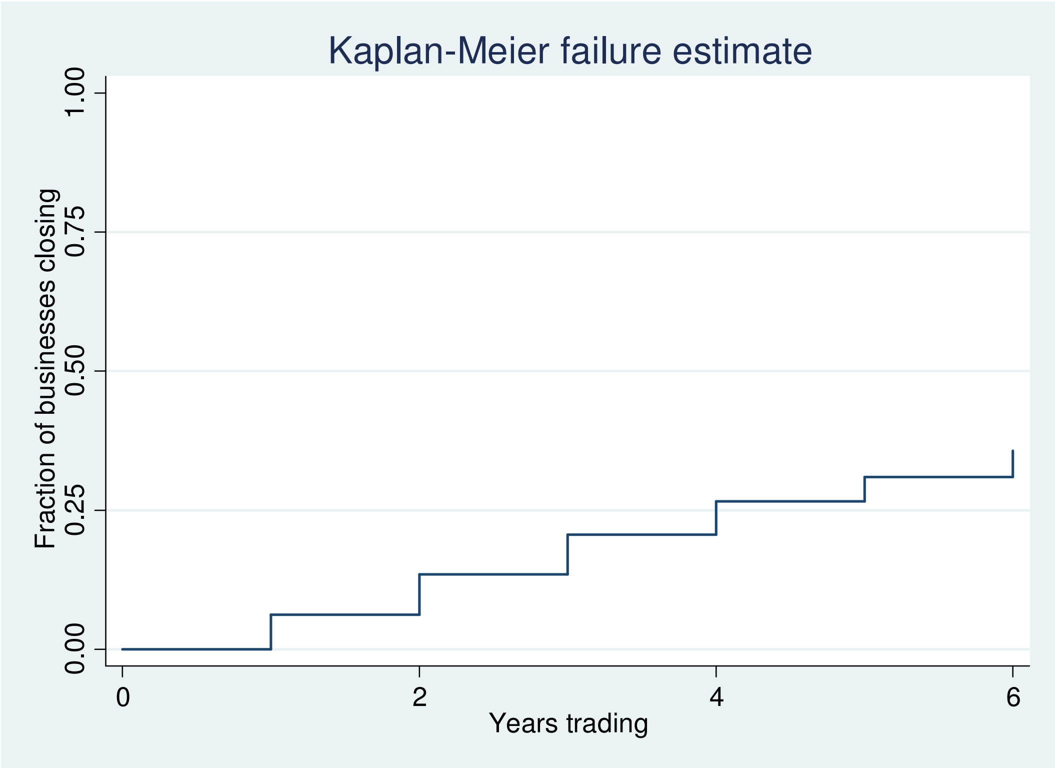


Figure 5: Cox hazard function (Model 4)

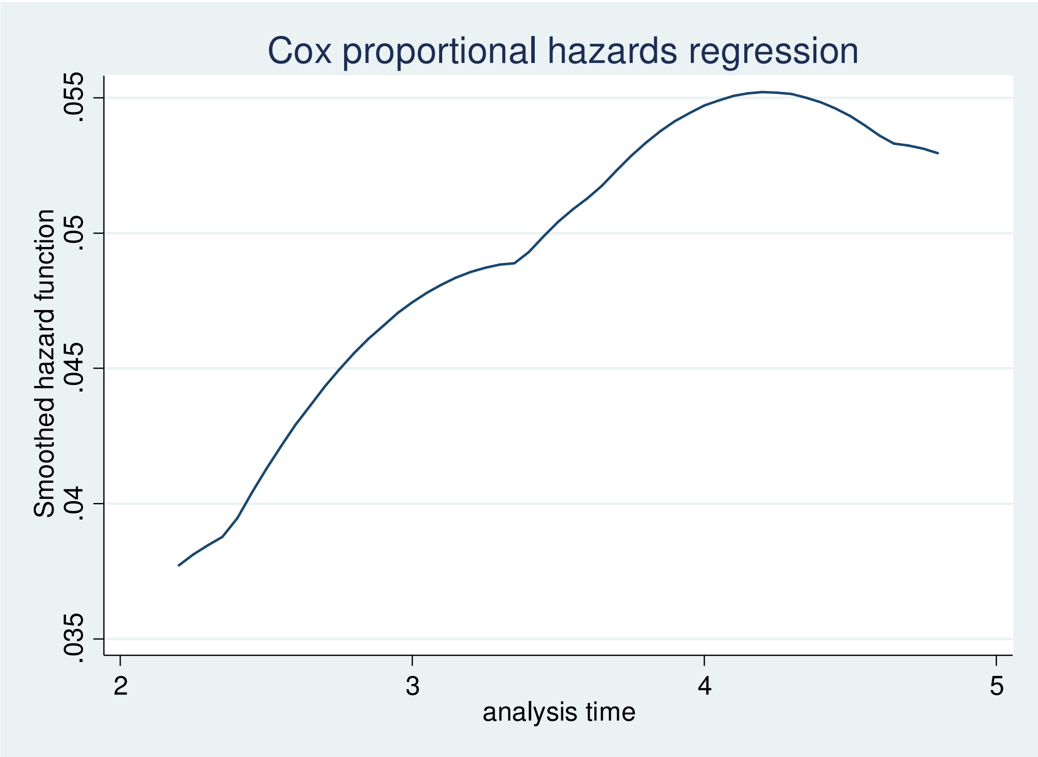


Figure 6: Hazard function shifts under rationing

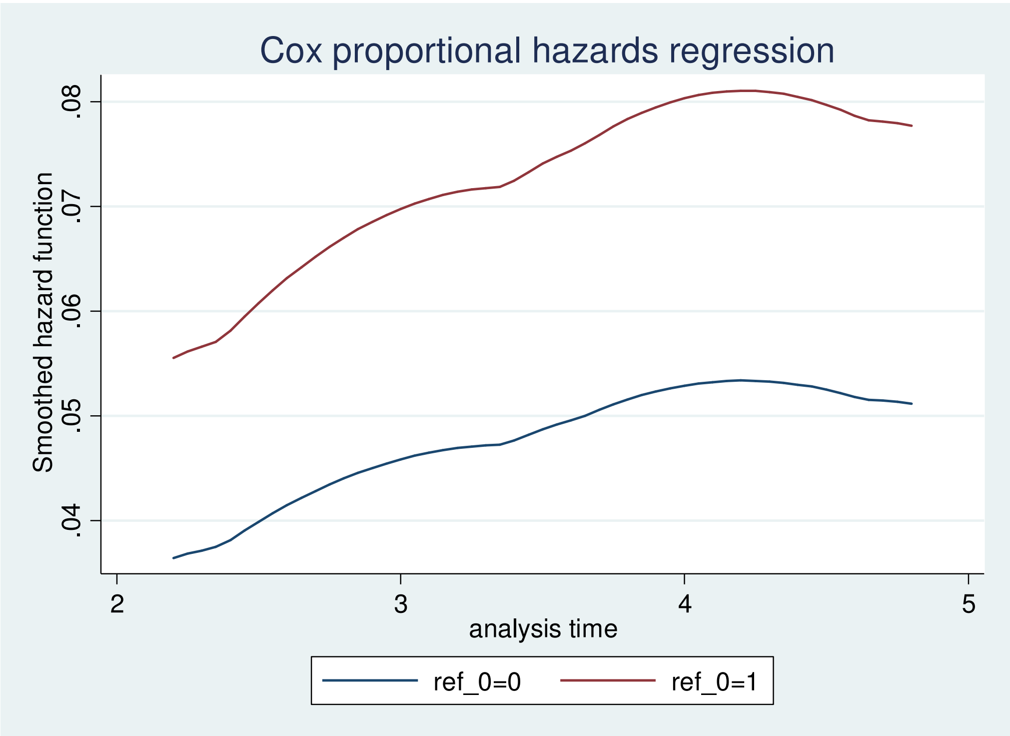


Table 1: Variable definitions

Factor	Variable	Definition
Closure	cess(i)	=1 if firm closed in the period 1994-2000; =0 for censored observation
	surv(i)	=1-cess (=1 if the firm did not close in the period 1994-2000) ;=0 else
	cessnow(it)	=1 in the year of closure (if the firm closed);= 0 else (censored observation)
Financial	req_0(i)	=1 if the firm requested a loan at startup; =0 else
	ref_0(i)	=1 if the firm requested a loan at startup and it was refused; =0 if requested a loan and was offered it;=0 else
	collrat(it)	=fixed assets/total assets, a measure of collateral availability
	debtrat(it)	= debt/(debt+equity)
	capex(it)	Capital expenditure by firm i at time t (000s French Francs)
	profit(it)	=profit of the business = (turnover +operating subsidies+financial products) - (consumption of raw materials and services + product taxes + netpayroll + employer's social security payments + depreciation + appropriation to reserves + loan costs) (000s French Francs)
	ODnew(it)	Overdraft (line of credit) drawdown (000s French Francs)
	bank2less(it)	Amount of bank loan if less than 2 years' duration (000s French Francs)
	bank2more(it)	Amount of bank loan if more than 2 years' duration (000s French Francs)
	ga(it)	Total assets of the business (000s French Francs)
	govaid(i)	=1 if the firm received 'public assistance' by way of a grant etc. ;=0 else
Human capital	prevunemp(i)	=1 if the entrepreneur had been unemployed prior to startup;=0 else
	maxdip(i)	=maximum education level of entrepreneur. =0 if none; =3 if University diploma (Degree)
	nodip(i)	=1 if the entrepreneur had no French Diploma;=0 else
	novice(i)	=1 if the entrepreneur has not been in business before;=0 else
	durexp10plus(i)	=1 if the entrepreneur had more than 10 years' work experience in the same area as the startup
	agef(i)	age of entrepreneur in years
Motivation	opportunity(i)	=1 if the main motive of the entrepreneur in starting up was because of a perceived business opportunity;=0 else
	runemp (i)	=1 if the main motive of the entrepreneur in starting up was unemployment
Employment	employ(it)	Number of full time employees
Legal	ltd(i)	=1 if the firm was a limited company;=0 else
Industry	houserve(i)	=1 if the firm is located in the Housing Services industry; =0 else.
	food(i)	Ditto Food industry
	manu(i)	Ditto Manufacturing
	construc(i)	Ditto Construction
	commerce(i)	Ditto Financial Services
	transport(i)	Ditto Transport
	busserv(i)	Ditto Business Services
	catering(i)	Ditto Catering
Competition	herf(it)	Herfindahl index (sum of squared turnover shares in industry turnover of firm i at time t)
Macro	ltintrat(%)(it)	Long term French interest rate (10 year Government bond rate).
	stintrat(%)(t)	Short term French interest rate (3 month Treasury bill rate)
	gdpgrowth(%)(it)	French GDP growth rate

Legend: Some of the variables vary across firms only and others across both firms and time. (it) refers to a variable that varies across firms (i) and with time and (t) one that varies only with time. In the statistical analysis we use lagged (x_1), squared (x2) and initial (x_0) values of the time-varying variables (x).

Table 2: Year one descriptive statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
		Panel A: Time-varying covariates – first year			
collrat	34927	.4032058	.3215728	0	8.7
debtrat	35047	.7973467	1.852376	-2	167.0909
bank2m	36535	21.57427	262.9085	0	9388
bank2p	36535	58.14958	419.0607	0	6925
ODnew	36535	10.5662	156.1587	0	9388
profit	36535	1020.251	4613.551	-16848	576672
ga	36535	633.0657	1760.421	0	100932
employ	36535	1.561407	4.749492	0	172
turn	36535	1068.333	4631.017	0	557197
ltintrat	36535	7.196016	.4630883	4.61	7.54
stintrat	36535	5.884587	.6947159	2.731939	6.625095
herf	36535	.0104151	.0086943	.0016269	.0368522
gdpgrowth	36535	1.99206	.2602687	1.1	3.2
		Panel B: Time-constant covariates			
req_0	36535	.4190502	.4934104	0	1
ref_0	15310	.0913782	.2881556	0	1
Cess	36535	.3684686	.482396	0	1
govaid	36535	.3939784	.4886368	0	1
Ltd	36535	.4623785	.4985894	0	1
male	36535	.7472013	.4346225	0	1
Agef	36535	37.43855	8.82259	22.5	52.5
maxdip	36535	1.366087	1.021456	0	3
nodip	36535	.2019707	.401476	0	1
unemp	36535	.50026	.5000068	0	1
durexp10plus	36535	.3156152	.4647668	0	1
durexpnul	36535	.0201998	.1406852	0	1
novice	36535	.7895169	.4076573	0	1
newidea	36535	.0927604	.2901003	0	1
taste	36535	.4859176	.4998085	0	1
opportunity	36535	.2598057	.4385339	0	1
runemp	36535	.1251403	.3308824	0	1
houseserve	36535	.0753798	.2640068	0	1
manu	36535	.0938005	.2915549	0	1
construc	36535	.1684138	.3742385	0	1
commerce	36535	.3209251	.4668385	0	1
transport	36535	.0468044	.2112226	0	1
busserv	36535	.1582866	.3650145	0	1

The table provides descriptive statistics for the weighted sample for time-varying covariates in the first year of trading (Panel A) and provides descriptives for time-constant covariates (Panel B) with the sample defined as the firms in existence in first year of trading. Panel A is a year-one snapshot taken in the first year of trading with means defined over the number of firms. *ref_0* has a smaller sample size than *req_0* because it has missing values when a firm does not request a loan. The definition of d*ebtrat =debt*/(*debt+equity*) means that debtrat can be greater than one if equity is negative. For variable definitions see Table 1.

Table 3: Mean differences between applicants for loans refused and those offered in startup year

	Group	Obs	Mean	Std. Err.	p-value for diff.	Mean ratio
			Time-invariant covariates			
cess	0	13911	.3025663	.0038949		
	1	1399	.4839171	.0133657	0.0000	1.60
agef	0	13911	36.90155	.0719148		
	1	1399	36.91744	.2233896	0.9460	1.00
govaid	0	13911	.4475595	.004216		
	1	1399	.3959971	.0130801	0.0002	0.88
unemp	0	13911	.5015455	.0042394		
	1	1399	.6161544	.0130068	0.0000	1.23
runemp	0	13911	.1079721	.0026314		
	1	1399	.2659042	.0118164	0.0000	2.46
opportunity	0	13911	.2772626	.0037955		
	1	1399	.1994282	.0106866	0.0000	0.72
maxdip	0	13911	1.316009	.0079601		
	1	1399	1.35168	.0274246	0.2118	1.03
durexp10plus	0	13911	.3206815	.0039574		
	1	1399	.2973553	.0122251	0.0697	0.93
			Time-varying covariates – first year			
collrat	0	13388	.5491831	.0024378		
	1	1349	.3864837	.0083178	0.0000	0.70
debtrat	0	13426	.8624433	.0117047		
	1	1358	.8243072	.0172147	0.0671	0.96
profit	0	13911	974.1454	27.51973		
	1	1399	662.6562	33.28349	0.0000	0.68
ga	0	13911	794.1556	12.18327		
	1	1399	393.3724	14.05892	0.0000	0.50
equity	0	13911	129.5065	3.318459		
	1	1399	77.76769	7.760346	0.0000	0.60
employ	0	13911	1.493063	.0299646		
	1	1399	1.311651	.0692609	0.0163	0.88
turn	0	13911	1060.396	27.77412		
	1	1399	709.6862	34.39498	0.0000	0.67

Table shows the sample means of the variables for firms refused a loan at startup (*ref_0*=1) and those offered (*ref_0*=0). Startup is defined as the first year of trading. T-stats for mean differences for which p-values are presented are based on a two-tailed test and use the Welch(1947) statistic which allows that the variances in the two states (refused and non-refused) may be unequal. The final column of the table shows the ratio of the mean values for refused to offered firms. (Thus a value less than 1 for variable x indicates that the mean value of x for a refused firm is less than that for an offered firm). For variable definitions see Table 1.

Table 4: Encompassing model: hypotheses on credit rationing

Hypothesis	γ_1	γ_2
H1: GEJ model with neither firm quality nor rationing	0	0
H2: EJ model with rationing	0	-
H3: GEJ with firm quality but no rationing	-	0
H4: GEJ model with firm quality and rationing	-	-

Table 5: Estimates of credit refusal and firm quality at startup

	Model 1 3SLS	Theoretical parameter	Model 2: IVprobit
	Ref_0 eqtn		**Ref_0 eqtn**
intercept	.3945543 (0.000)		.6006777 (0.000)
surv	-.3153457 (0.000)	γ_1	-1.805639 (0.000)
collrat	-.163195 (0.000)	γ_2	-.6845349 (0.000)
	Surv eqtn		**Surv eqtn**
intercept	.5642237 (0.000)		.501103 (0.000)
collrat	..		.0604303 (0.000)
ref_0	-.3787783 (0.000)	π_{11}	..
agef	.0056992 (0.068)	π_{12}	.0055341 (0.117)
agef2	-.0000695 (0.093)	π_{13}	-.0000692 (0.138)
maxdip	.0168588 (0.000)	π_{14}	.0174717 (0.000)
durexp10plus	.0537892 (0.000)	π_{15}	.0579489 (0.000)
opportunity	.0320264 (0.000)	π_{16}	.0325097 (0.000)
unemp	-.0499724 (0.000)	π_{17}	-.0552842 (0.000)
runemp	-.1353147 (0.000)	π_{18}	-.1358043 (0.000)
herf	6.257245 (0.000)	π_{19}	6.586931 (0.000)
herf2	-127.6589 (0.000)	$\pi_{1,10}$	-135.9258 (0.001)
Ind cntrls?	Yes		Yes
Nobs	14737		14737
Chi2(df) ref_0 eqtn	487.97(2) (0.000)		1718.88(2) (0.000)
Chi2(df) surv eqtn	772.63(15) (0.000)		..
Chi2(df) Exog	..		105.07(1) (0.000)

Table 6: Survival and closure of the startups over time

Time	Beginning no at risk	Closures In year	Censored Firms	Survivor Function
1	36535	2287	1607	0.9374
2	32641	2504	669	0.8655
3	29468	2435	813	0.7940
4	26220	1968	1354	0.7344
5	22898	1356	5737	0.6909
6	15805	1096	15000	0.6430

Table reports the Kaplan-Meier survival table data for the weighted sample. Time, or in the jargon of the literature, *analysis* time, is measured in years from startup so that all cohorts can be included. Thus, time=1 means the first year of trading for the company. It corresponds to different calendar years depending on the startup date of the company or the cohort to which it belongs. Note that the startup numbers are larger than those reported in Table 5 due to the fact that the former are conditioned on non-missing values for all regressors. The Kaplan-Meier calculations are not so conditioned.

Table 7: Estimates of the Cox hazard of closure

Variable	Model 1: Linear, Initial Values	Model 2: Linear, Current Values	Model 3: Linear, Lagged values
ref_0	.4549085 (0.000)	.4529336 (0.000)	.5897475 (0.000)
Collrat	-.0148229 (0.915)	-.0140315 (0.911)	.1390756 (0.378)
Debtrat	.0264402 (0.000)	.0117881 (0.008)	.0148894 (0.033)
Equity	-.0005399 (0.009)	-.0003001 (0.000)	-.0003176 (0.000)
Capex	.0000253 (0.864)	-.0006461 (0.032)	-.0008087 (0.003)
ODnew	.0001651 (0.701)	-.0000933 (0.781)	-.0000734 (0.761)
newbank2m	-.0001647 (0.670)	.0001587 (0.503)	.0001282 (0.467)
newbank2p	-.0000476 (0.793)	.0000745 (0.612)	-.0000623 (0.646)
Ga	-.0001502 (0.222)	-.0001975 (0.007)	-.0000879 (0.094)
Nodip	.0870982 (0.283)	.0894473 (0.271)	-.0082172 (0.935)
Agef	-.0530914 (0.114)	-.064498 (0.051)	-.0853275 (0.039)
agef2	.000733 (0.102)	.0008959 (0.042)	.0011777 (0.032)
durexp10plus	-.2927362 (0.000)	-.3325049 (0.000)	-.3230213 (0.001)
Unemp	.169153 (0.017)	.1394521 (0.046)	.131142 (0.122)
Novice	-.1272669 (0.198)	-.1457023 (0.134)	-.1275889 (0.284)
Runemp	.1781249 (0.068)	.1715233 (0.075)	.2077008 (0.072)
opportunity	-.134664 (0.097)	-.1837945 (0.022)	-.1343081 (0.145)
Ltd	-.2701694 (0.002)	-.1688307 (0.053)	-.365762 (0.000)
Herf	-17.4671 (0.000)	-19.67621 (0.000)	-22.1891 (0.000)
gdpgrowth	-.2950127 (0.067)	-.3254203 (0.197)	-.9326422 (0.000)
Ltintrat	-1.13965 (0.000)	-.1463329 (0.694)	-1.493646 (0.000)
Stintrat	.5865847 (0.001)	.0686481 (0.747)	.9404485 (0.000)
Nobs	28421	28815	21950
Nfirms	14730	15027	13311
Nclosures	4059	4052	2949
Wald Chi2(df)	219.03(22) (0.000)	214.62(22) (0.000)	246.26(22) (0.000)
AIC	28773.51	28823.33	20872.82

Table reports estimates of the Cox proportional hazard rate for businesses requesting loans at startup. Figures in brackets below the coefficients are p-values. To save space, the x_0 notation is dropped for initial values in Models 1-4. Firm-clustered standard errors underlie these statistics. TVC stands for Time-Varying Covariate.

Table 7 continued

Variable	Model 4: Initial Current quadratic	Model 5: Initial, current Quadratic TVC
	Coef. (p-value)	Coef. (p-value)
Main		
ref_0	.421148 (0.000)	.6459951 (0.019)
collrat	-.8602543 (0.015)	-.8483348 (0.016)
collrat2	.7001258 (0.021)	.6931043 (0.022)
Debtrat_0	.1194314 (0.000)	..
Debtrat_0sq	-.0015641 (0.000)	..
debtrat	.0475246 (0.003)	.0458508 (0.003)
debtrat2	-.0003734 (0.024)	-.0003495 (0.028)
equity	-.0006193 (0.000)	-.0006345 (0.000)
equity2	-5.41e-08 (0.002)	-5.49e-08 (0.001)
capex	-.000635 (0.015)	-.0006456 (0.015)
capex2	8.01e-08 (0.003)	8.23e-08 (0.002)
ga	-.0002224 (0.000)	-.0002228 (0.000)
ga2	8.30e-09 (0.000)	8.34e-09 (0.000)
agef	-.0546849 (0.074)	-.0549677 (0.072)
agef2	.0007623 (0.062)	.00077 (0.059)
unemp	.1852587 (0.004)	..
runemp	.1970708 (0.035)	.1913055 (0.041)
durexp10plus	-.2233383 (0.003)	-.2254862 (0.002)
herf_0	-7.24568 (0.048)	-7.257693 (0.047)
opportunity	-.1400437 (0.068)	-.1401604 (0.067)
ltintrat	.1025525 (0.137)	.0981239 (0.155)
Ind cntrls?	Yes	Yes

Table 7 continued

TVC	Model 4 Initial Current quadratic	Model 5: Initial, current Quadratic TVC
unemp	..	.4812911 (0.001)
debtrat_0	..	.2296398 (0.000)
debtrat_0sq	..	-.0036324 (0.007)
Ref_0	..	-.5622377 (0.327)
Chi2(df) (p-value)	461.67(24) (0.0000)	384.33(25) (0.0000)
N obs	28316	28316
N firms	14741	15027
N failures	4572	4642
Table reports estimates of the Cox proportional hazard rate of closure for businesses requesting loans at startup. Figures in brackets below the coefficients are p-values. To save space, the x_0 notation is dropped for initial values in Models 1-4. Firm-clustered standard errors underlie these statistics. TVC stands for Time-Varying Covariate.		

Appendix 1: The EJ model

The entrepreneur solves.

$$Maximise_k \pi(k) = \theta f(k) - r[k - z] \tag{1}$$

Subject to

$$k - z \leq az, \quad a \in (0,1) \tag{2}$$

where

$$k = capital\ in\ the\ business$$

$$\theta = entrepreneurial\ ability$$

$$r = 1 + rate\ of\ interest$$

$$z = collateralisable\ assets\ of\ the\ business$$

$$f(k) = a\ concave\ production\ function\ of\ capital;\ f' > 0, f'' < 0$$

Inequality (2) (which represents EJ's assumption that the bank downscales the value of the entrepreneur's assets to arrive at its collateral value) can be more conveniently written as

$$k \leq bz, \quad b = 1 + a > 1 \tag{3}$$

The solution to this problem is a level of capital

$$k = k^*(\theta, r), \ \ k_\theta^* > 0, \ \ k_r^* < 0 \tag{4}$$

and an optimal value function

$$\pi = \pi^*(\theta, bz, r) = \theta f(k^*) - r[k^* - z] \tag{5}$$

The probability of a credit constraint ($k^* > bz$) for firm θ is given by

$$Prob(constraint = 1|\theta) = \begin{cases} 1\ if\ k^* > bz \\ 0\ else \end{cases} \tag{6}$$

Thus if the k* which solves this problem is less than bz then the business is credit-unconstrained. If the reverse, it is credit-constrained. Note that the loan offered by the bank for a constrained entrepreneur is

$$\bar{k} - z = az \quad (7)$$

whereas the loan requested was

$$k^* - z > az \quad (8)$$

Hence *downscaling* of the entrepreneur's request by the bank occurs for constrained borrowers. In the extreme case of downscaling, namely rationing (inefficient loan denial), we have

$$\bar{k} - z = az = 0 \quad (9)$$

which implies that either $z = 0$ (entrepreneur has no collateralisable assets)[xl] or $a = 0$ (bank values the entrepreneur's assets at zero). Thus the probability of credit *rationing* in EJ is

$$Pr\ (a = 0\ or\ z = 0\ or\ a = z = 0|\theta) \quad (10)$$ [xli]

The probability of failure (business closure) is defined by the ability of the marginal entrepreneur, θ_0. This level of talent separates viable from nonviable businesses. Those with ability above θ_0 survive and those with ability below do not. We have two cases to consider for the marginal entrepreneur:

1. *The unconstrained entrepreneur*

   Using 5 above maximum net profits for the marginal entrepreneur are by definition

   $$\tilde{\pi}(\theta) \equiv \pi\{k^*(\theta)\} - (w + rz) = \theta f\{k^*(\theta)\} - rk^*(\theta) - w \quad (11)$$

   Hence we get

   $$\left.\frac{\partial\theta}{\partial z}\right|_{\tilde{\pi}=0} = 0 \quad (12)$$

i.e., a change in assets has no effect on the entrepreneurial ability cutoff and hence the probability of failure, namely, $\Pr(\theta < \theta_0)$.

2. *The constrained entrepreneur*

Net profits for the marginal entrepreneur are now

$$\tilde{\pi}(\theta, z) \equiv \pi(bz) - (w + rz) = \theta f(bz) - rbz - w \tag{13}$$

Setting this expression to zero and solving for θ we get

$$\theta_0 = \frac{rbz+w}{f(bz)} \tag{14}$$

The probability of failure is thus

$$\Pr(\theta < \theta_0) = G\left\{\frac{rbz+w}{f(bz)}\right\} \tag{15}$$

where G(x) is the cdf of x. Differentiating wrt z we get

$$\frac{\partial Pr}{\partial z} = g\{.\}f(bz)[r - \theta f'(bz)]b/f(bz)^2 < 0 \tag{16}$$

where g(x) is the density of x and we have used the FOC for the constrained maximum to show that the term in square brackets is negative. Thus, more assets under credit constraints reduces the chances of failure *in the population.*

Appendix 2: The GEJ model

The entrepreneur's problem

We adapt the EJ assumptions by adding in a human capital element, q, into the entrepreneur's production function. We also assume, along with EJ, that the entrepreneur believes that his return is certain. Thus the chances of bankruptcy*, as seen by the entrepreneur*, are zero[xlii]. The entrepreneur thus solves

$$Maximise_{l,q}\ \pi = f(k,q) - \frac{l^{1+r}}{1+r} - wq \tag{1A}$$

where total capital, k, is the sum of the entrepreneur's assets and her borrowing:

$$k = z + l \tag{2A}$$

and w is the unit cost of improving the entrepreneur's skills or human capital. This yields FOC

$$0 = \pi_l = f_k - l^r \tag{3A}$$

$$0 = \pi_q = f_q - w \tag{4A}$$

The SOCs require that

$$\pi_{ll} < 0,\ \pi_{qq} < 0 \tag{5A}$$

and

$$D = \begin{vmatrix} f_{kk} - rl^{r-1} & f_{kq} \\ f_{qk} & f_{qq} \end{vmatrix} = (f_{kk} - rl^{r-1})f_{qq} - f_{kq}^2 > 0 \tag{6A}$$

It is easily verified that 6A holds if we assume a Cobb-Douglas production function with diminishing returns to scale, i.e. one of the form:

$$f(k,q) = Ak^{\alpha}q^{\beta},\ 0 < \alpha, \beta < 1;\ \ \alpha + \beta < 1 \tag{7A}$$

Using Cramer's rule we find that optimal skills of the entrepreneur are increasing in assets

$$\frac{\partial q}{\partial z} = \begin{vmatrix} f_{kk} - rl^{r-1} & f_{kq} \\ f_{qk} & f_{qq} \end{vmatrix} D^{-1} = rl^{r-1} f_{kq} D^{-1} > 0 \tag{7A}$$

The latter result follows from the assumption of a Cobb-Douglas production function. Likewise, borrowing is decreasing in assets:

$$\frac{\partial l}{\partial z} = \begin{vmatrix} -f_{kk} & f_{kq} \\ -f_{qk} & f_{qq} \end{vmatrix} D^{-1} = \left(-f_{kk}f_{qq} + f_{kq}^2\right)D^{-1} < 0 \; iff \; \alpha + \beta < 1 \tag{8A}$$

This is consistent with the idea that internal funds are preferred by the entrepreneur over external because the latter are more expensive. Thus borrowing is reduced when internal cash stocks increase.

The bank's problem

The bank is a realist and knows that entrepreneurial ventures have a positive probability of bankruptcy. Moreover has a database on which to estimate this probability. The bank solves

$$maximise_{\hat{s}}\; V = Emax\{\, p(s,q)rl + [1 - p(s,q)]z,\; \rho l\}$$

$$= \int_0^{\hat{s}} \rho l d\Gamma(s) + \int_{\hat{s}}^1 \{p(s,q)rl + [1 - p(s,q)]z\} d\Gamma(s) \tag{9A}$$

The First Order Condition (FOC) for this problem is

$$0 = V_{\hat{s}} = \rho l \widehat{\gamma} - \{\widehat{p} r l + (1 - \widehat{p})z\}\widehat{\gamma} \tag{10A}$$

where $\hat{p} = p(\hat{s}, q)$ and $\hat{\gamma} = \Gamma'(\hat{s})$ and p is increasing in both arguments. Solving for p, the bank-optimal success probability, we get:

$$p(\hat{s}, q) = \frac{\rho l - z}{rl - z} \tag{11A}$$

This generates the optimal cutoff signal $\hat{s}$ of the form

$$\hat{s} = \varphi(q, z; r, \rho) \tag{12A}$$

A probability of bankruptcy of the form

$$\hat{p} = \tau(q, z; r, \rho) \tag{13A}$$

And finally a probability of rejection (loan refusal)

$$\Pr(Refusal) = \vartheta(q, \hat{p}, z; r, \rho) \tag{14A}$$

Equilibrium

We now bring together the results of the Entrepreneur's and the Bank's problem and investigate the derivatives of 12A-14A. We assume throughout that two conditions hold. Firstly, that the safe rate is less than the risky rate and secondly that the Cobb-Douglas production function satisfies diminishing returns to scale.

We have assumed that the bank's estimate of the firm's probability of success, p, is a positive fraction. This implies from 11A that

$\rho l > z$ and $rl > z$ (13A)

or that

$\rho l < z$ and $rl < z$ (14A)

However, the second order condition on the Bank's problem

$0 > V_{\hat{s}\hat{s}} = -\hat{p}_s(rl - z)$ (15A)

rules out 14A. Hence 13A must hold. Then, on differentiating the FOC 10A and using 15A we find that the entrepreneurship cutoff is decreasing in human capital q:

$$\frac{\partial \hat{s}}{\partial q} = \frac{\hat{p}_q[rl - z]}{V_{\hat{s}\hat{s}}} < 0$$

(16A)

Thus, credit refusal (rationing) is also decreasing in human capital:

$$\Pr(Refusal) = \Pr(s < \hat{s}) \tag{10A}$$
$$= \hat{\gamma}\,\frac{\partial \hat{s}}{\partial q} < 0$$

where $\hat{\gamma}$ is the density of the signal s. Likewise we find the entrepreneurship cutoff is decreasing in collateral:

$$\frac{\partial \hat{s}}{\partial z} = \frac{(r - \rho)(zl_z - l)}{rl - z} < 0$$

(11A)

Since the first term in the numerator is positive by assumption and the second is negative using 8A above. 11A then implies that the probability of refusal is decreasing in assets/collateral:

$$\frac{\partial \Pr(Refusal)}{\partial z} = \frac{\partial \Pr(s < \hat{s})}{\partial z}$$
$$= \hat{\gamma} \frac{\partial \hat{s}}{\partial z} < 0$$

(12A)

Entrepreneurs with better skills and those with greater assets are thus more likely to get a loan. See Figure 3.

Our other equation relates to survival. Note that the optimal the probability of success is given by equation 11A. Differentiating this totally with respect to q we get

$$\frac{d\hat{p}}{dq} = \frac{\partial \hat{p}}{\partial \hat{s}} \frac{\partial \hat{s}}{\partial q} + \frac{\partial \hat{p}}{\partial q} > 0 \ \ if\ and\ only\ if\ \frac{\partial \hat{p}}{\partial q} > -\frac{\partial \hat{p}}{\partial \hat{s}} \frac{\partial \hat{s}}{\partial q}$$

(13A)

which we shall assume (for definiteness) to be true: human capital (q) increases the chances of success (p) directly but also indirectly reduces the entrepreneurship cutoff ($\hat{s}$) in order to (optimally) increase the chances of loan acceptance. We can also see that

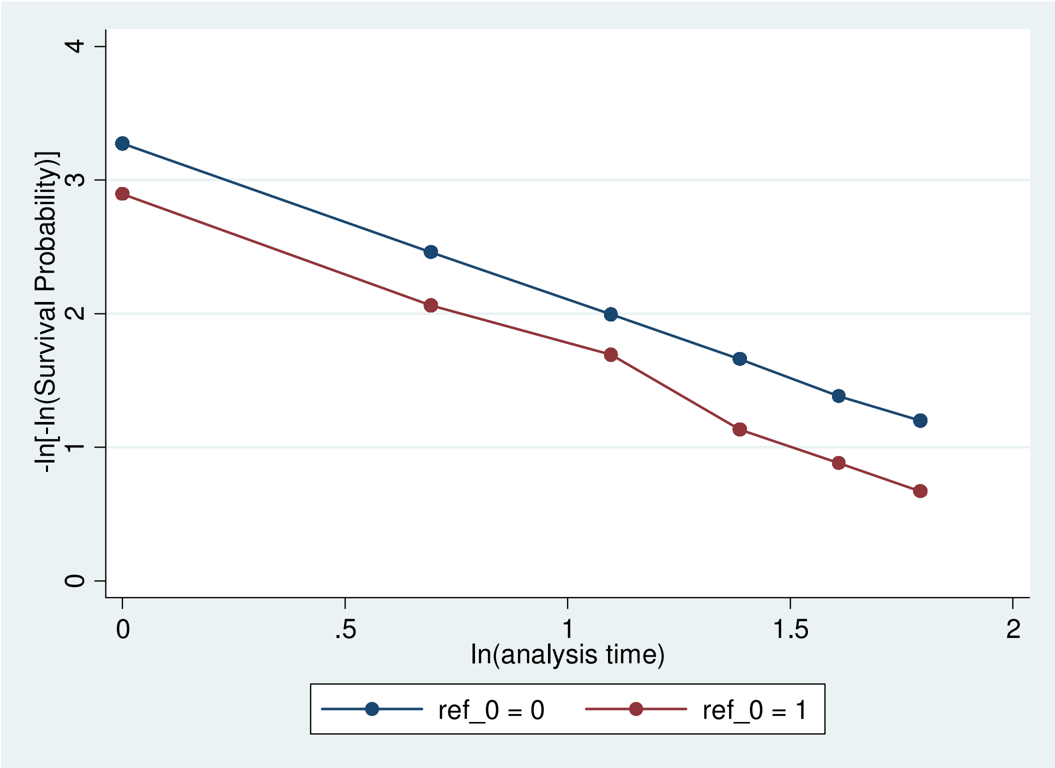
$$\frac{d\hat{p}}{dz} = \frac{\partial \hat{p}}{\partial \hat{s}} \frac{\partial \hat{s}}{\partial z} + \frac{\partial \hat{p}}{\partial z} q'(z) > 0 \ if\ \frac{\partial \hat{p}}{\partial z} q'(z) > -\frac{\partial \hat{p}}{\partial \hat{s}} \frac{\partial \hat{s}}{\partial z}$$

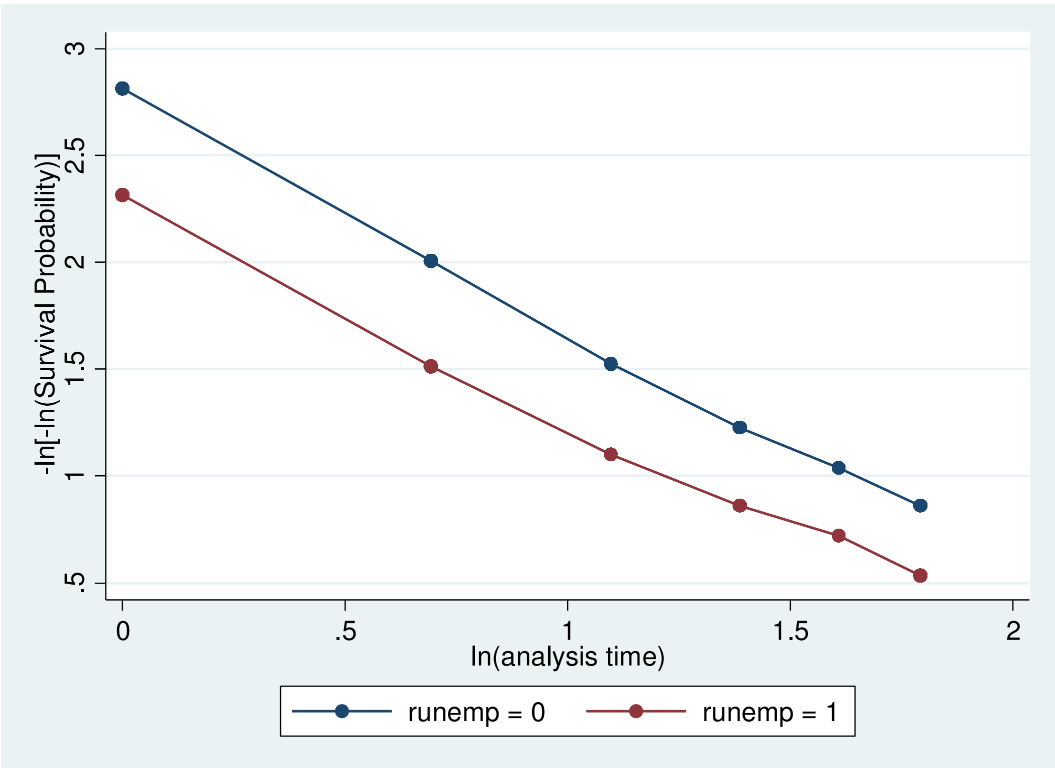
(14A)

which again we shall assume for definiteness to hold[xliii]. Thus the probability of survival is increasing in human capital and in assets. We can also show (derivation not presented) that the probability of loan refusal and the probability of success are decreasing in the interest rate

Appendix 3:

Diagnostic tests of the Cox model





Appendix 4:

Economic impacts on hazard of changes in variables

Variable	Permanent shift (%) Elasticity	Temporary shift (%), half-life 2 yrs	
		Year 0	Year 5
	+91% NA	0	0
collrat (10% increase)	-4% -0.4	0	0
debtrat (10% increase)	+0.4% +0.04	0	0
durexp10plus	-20% NA	0	0
herf_0 (10% increase)	-0.9% -0.09	0	0
runemp	+21% NA	0	0
opportunity	-13% NA	0	0
ltintrat	0% 0	0	0
agef (10% increase)	-18.5% -1.8	0	0
unemp	0% NA	+62% 6.2	8.7% .87
debtrat_0	0% 0	+1.9% .19	0.32% 0.032

Table shows the marginal effects on the hazard ratios of changes in key variables assuming a half life of 2 years or an instantaneous rate of decay of 35%. Coefficients are taken from Model 5 of Table 7.

Endnotes

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[i] Exceptions include Taylor(1999) and Cosh, Cumming and Hughes(2009) for the UK. Whilst making significant contributions, these papers are restricted to very short panels and control for a very limited set of variables in comparison with the present study.

[ii] The econometric implementation of their model of course introduces a stochastic error term into their equations but this is not part of their *theoretical* model and in particular does not allow for uncertain bankruptcy.

[iii] Recent large cross-country studies by the World Bank singularly fail to meet both these criteria. See for example, Beck and Demirguc-Kunt(2006); Ayyagari,Beck andDemirguc-Kunt (2007); Beck(2007).

[iv] There are, as recent events have shown, very significant imperfections in the banking systems of the US and the UK, and these have impacted the availability of credit to small firms. However, this has largely been due not to the practice of collateral-based lending but rather to the banks' desire to build up cash to reduce the excessive leverage of the early 2000s.

[v] As mentioned before, there is no uncertainty in this model at the level of the individual firm: either it survives with probability 1 if it makes profits; or it fails with probability 1 if it does not.

[vi] We call r the interest rate for brevity but it is in fact 1+the interest rate.

[vii] We shall assume in the empirical work and in line with Cressy(1996) that q is a function of a vector of exogenously given human capital variables along with industry and macro factors.

[viii] See Abdesselam et al (2002) for more detail than is provided here. We define a cohort as the set of firms starting trading in a given year. Thus they are deemed to start up only once financial data becomes available.

[ix] Because the sample is stratified we use sample weights (inverses of sampling probabilities) in the empirical work to follow.

[x] We are not able to distinguish these two outcomes in our data and so cannot address this so-called 'discouraged borrower' phenomenon. See Kon and Storey(2003).

[xi] Strictly, finance constraints exist under these circumstances only if all possible finance sources have been exhausted. Nonetheless, given customer lock-ins, for most businesses the choice of external finance is limited to a bank loan from a specific bank. See Cosh, Cumming and Hughes(2009), however, for an interesting exploration of finance choice using UK data.

[xii] The counterpart $succ = 1 - cess$ will also be useful in what follows.

[xiii] By definition, we have no financial and employment data on time-varying covariates for firms that do not start trading in 1994,1995 or 1996 but who were nonetheless classified as business start-ups in that year. For these we do however have biographical, time-constant, data on entrepreneurial characteristics etc. Hence we calculate descriptive statistics for the first year of trading for such businesses.

[xiv] Cressy(1996) found in the NatWest dataset for the UK about one quarter of the sample were limited companies.

[xv] This is consistent with Cressy's(1996) findings for the UK in 1990.

[xvi] Bear in mind that we do not have data on discouraged borrowers who may be potentially rationed. By definition these potential borrowers did not apply for a loan.

[xvii] From Table 1 we define *collrat* as the ratio of fixed to total assets. Describing this as a measure of collateral availability assumes that there is not already a fixed or floating charge on the assets before the loan is requested. Whilst we cannot test this assumption, we believe it to be reasonably valid as we shall show from the empirical results to follow. It is also used by other researchers in the area, e.g. Bridges and Guariglia(2008).

[xviii] See Table 1 for the definition of the profit variable.

[xix] For example, two authors report that a major UK bank carried out an analysis of survival rates of start-ups in the late 1980s and early 1990s. This effectively used only cross-sectional analysis. See Cressy and Storey(1994).

[xx] We can think of q(x) as a shift parameter for p in the formula for the optimal probability of success, equation 23. This enables us to write loan refusal ref_0* as a function of the probability of success and to model this implicitly as a function of human capital in regression equation 28.

[xxi] This hypothesis is derived from intuition and casual observation rather than the academic literature or the theory introduced in this paper.

[xxii] Note that the *collrat* variable in equation 1 identifies equation 3 in the system.

[xxiii] Since quality is substantially a function of human capital variables this result is also consistent with Cressy(1996).

[xxiv] It is worth noting also that the signs and significance of most of the other variables in the *succ* equation are as predicted in the literature. Perception of a business opportunity (*opportunity*), owner flesh in the game (*equity_0*) and profits all increase business quality as do owner education (*maxdip*) and relevant work experience (*durexp10plus*). By contrast, unemployment experience (*unemp*) and labour market push factors (*runemp*) reduce it. Government assistance has a strong positive impact on business quality whilst financial risk (*debtrat_0*) reduces it. Initial market power of the business (*herf_0*) likewise is associated with higher business quality in the eyes of the bank. One exception to the rule is *agef* which, although of the right sign, is statistically quite insignificant.

[xxv] For a second robustness check we present in an unpublished Appendix, available from the authors on request, the 3SLS estimation of a much larger model where we allow that each of *ref_0, surv, collrat, bank2m* (short term bank loan) and *lga* (log of total assets) is potentially endogenous. The estimation confirms the findings of Table 5.

[xxvi] Startup, defined as when the first accounts become available, and hence the first record of actual *trading*, occurs until 1999, but by then the numbers are very small. All cohorts, however, are represented in the empirical analysis of this paper. We assume that firms that do not trade until a year after 1994 are not 'at risk' of failure before the first trading date. This is intuitively plausible and in line with the behaviour of what bankers call 'latent' business accounts.

[xxvii] In the Kaplan-Meier table the probabilities are not conditioned on covariates so the pattern of survival will be somewhat different from the Cox estimates presented later.

[xxviii] Note however, they are not *functions* of time. We shall explain how time-functions can be built into the model without violating its assumptions later.

[xxix] To do this we respecify the hazard (17) as

$$h(t) = h_0(t)\exp(\beta_1 x_1 + \cdots + \beta_k x_k + \gamma_1 z_1 g(t) + \gamma_2 z_2 g(t) + \cdots + \gamma_l z_l g(t)$$
$$= h_0(t) exp\ (\beta' x + \gamma' z g(t)) \qquad (17a)$$

where γ is a vector of additional coefficients to be estimated. This formula retains the proportional hazard specification as the g(t) function cancels. The precise form of the time function can be chosen by the researcher, and experimentation showed that an exponentially declining function of time performed best. The hazard of closure estimated is conditioned on the bank's (known) decision on whether or not to offer a loan. The results are presented in Table 8 below.

[xxx] Several of the variables in the current values model are potentially be endogenous, the most obvious of which are firm size (*ga*), equity value (*equity*), the debt ratio (debtrat), overdraft level (*ODnew*) and short term loan (*newbank2m*). By choosing lagged values of these variables we can be sure that the hazard of closure does not influence them in addition to their influencing closure. This it does well: although the t-stats and coefficients differ slightly from the current and initial models they are qualitatively identical to those of model 2 for all variables except unemp, *opportunity, gdpgrowth, stintrat* and *ltintrat,* none of which are candidates for endogeneity.

[xxxi] This mirrors the findings for the UK in this period. These two variables are therefore dropped in models 4-6.

[xxxii] Several of these results confirm those of earlier studies discussed above. In particular, the concave effect of entrepreneurial age first identified in Cressy(1996) is very strongly evident in all models.

[xxxiii] Both variables are dropped in models 4-6 for that reason. Bates(1990) showed on US data that the finance variables are a function of human capital variables.

[xxxiv] This is verified by running a simple fixed effects regression of *newbank2p* on *collrat* and its square. We find that loan size is highly significantly increasing in collateral availability (p=0.000 for both variables).

[xxxv] This meshes well with the results for Portugal – see Geroski et al (2010).

[xxxvi] We assume a half life of 2 years for the initial effects. However, nothing hangs on this: we tried different rates of decay and different functional form (linear) and found qualitatively no difference. Results are available from the authors on request.

[xxxvii] One cannot generate a hazard function for the TVC models so none is presented. See Cleves et al(2010) for details. Note also that since a hazard rate requires two years of data to calculate, no hazard rate for year 6 is shown in the chart.

[xxxviii] There are two unexplained kinks in the curve that require further investigation. This is reserved for future work.

[xxxix] If anything the curves show a slightly increasing difference over time so that refused firms are more than 50% more likely to close by year 5.

[xl] In our dataset there are 353 firms with no collateralisable assets (27% of the total) which were refused a startup loan, whereas there are 14,957 firms with collateralisable assets (9% of the total) that were refused a startup, loan indicating that lack of collateral tripled the probability that a loan would be refused. However, contrary to the EJ model, zero collateral is not certain to result in loan denial.

[xli] In EJ it is assumed that α is a constant for all entrepreneurs, which is again a rather restrictive assumption, and one that we shall drop. There is good reason to allow the downscaling to vary across entrepreneurs, in particular across their industry of location Different industries will have different levels of liquidity associated with companies' assets, e.g. in the high tech sector, much of the assets will be entrepreneur-specific and so not easily sold.

[xlii] This can also be interpreted as entrepreneurial optimism. See De Meza and Southey(1996).

[xliii] Both of these assumptions are adopted in order to get a plausible sign in the regressions. The empirics on the one hand determine whether the theory variables are relevant (significant) and on the other, the signs of the variables. As we shall see the empirics demonstrate the plausibility of the predictions and hence, on Friedman's (1963) logic, the plausibility of the assumptions. We therefore adopt a two tailed test on the variables in question to allow for either sign to the coefficients.