TI 2004-106/3
Tinbergen Institute Discussion Paper

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Version: March 2005

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Schooling, Capital Constraints and Entrepreneurial Performance: The Endogenous Triangle

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SCHOOLING, CAPITAL CONSTRAINTS AND ENTREPRENEURIAL PERFORMANCE: THE ENDOGENOUS TRIANGLE

Abstract

To what extent is the performance of a small business venture, once started, affected by capital constraints at the time of inception and by the business founder's investment in human capital? We attempt to answer this question taking into account the potential endogeneity of human and financial capital, and also possible interdependence between these variables. A theoretical model is developed which generates predictions about the nature and directions of the interdependencies. Using a rich data set on Dutch entrepreneurs in 1995, we obtain findings that are broadly consistent with the theoretical model. Instrumental variable estimates indicate that a 1 percentage point relaxation of capital constraints increases entrepreneurs' gross business incomes by 3.9 per cent on average. Also, education enhances entrepreneurs' performance both directly – with a rate of return of 13.7 per cent — and indirectly, because each extra year of schooling decreases capital constraints by 1.18 percentage points. The indirect effect of education on entrepreneurs' performance is estimated to be between 3.0 and 4.6 per cent.

1 Introduction

Entrepreneurship is becoming an increasingly prominent issue in both academic and policy circles. Entrepreneurs are often credited with innovating new products, discovering new markets, and displacing ageing incumbents in a process of 'creative destruction'. But it is also recognised that if entrepreneurs face constraints such as limited human or financial capital, then these economic benefits might not be realised. This realisation has prompted several governments to devise public programs to encourage entrepreneurship. Some are human capital based (e.g., subsidies to enterprise education in schools and colleges, enterprise training and science parks), while others address perceived financial constraints (e.g., loan guarantee schemes, grants, and tax incentives for venture capital investments). Underlying these programs is a belief that human and financial capital constraints exist, and that they retard entrepreneurship and entrepreneurs' performance. But there is still little agreement among researchers about the actual extent of human and financial constraints, and their impact on entrepreneurs' performance in practice.

In this paper we ask: To what extent is the performance of a small business venture, once started, affected by capital constraints at the time of inception and by the business founder's investment in human capital? In particular, can we measure the distinct contribution of each of these factors, taking account of the possibility that human capital might also have an indirect effect on performance by making financial capital easier to access and so diluting any capital constraints? Using a sample of data from a rich survey of entrepreneurs conducted in the Netherlands in 1995, we test empirically three propositions that follow from a simple theoretical model:

1. Capital constraints have a negative effect on average on entrepreneurs' performance.
2. Greater human capital has a positive effect on average on entrepreneurs' performance.
3. Greater human capital has a negative effect on capital constraints.

The contribution of this paper is threefold. First of all, we model entrepreneurs' capital constraints as an endogenous variable (measured on a continuous scale), and assess the causal effect of these constraints on entrepreneurs' performance. This is novel, as previous empirical research has explored the effects of financial wealth, rather than of capital constraints *per se*; and much of it has treated financial wealth as exogenous.[1] We argue that treating capital constraints as endogenous yields useful insights into their composition, while enabling the effects of these constraints on entrepreneurs' performance to be estimated consistently. Endogeneity of error terms in performance and capital constraint equations can be caused by inherent

[1] See, e.g., Fazzari *et al* (1988), Evans and Jovanovic (1989), Bates (1990), Cooper *et al* (1994), Holtz-Eakin *et al* (1994), Cressy (1996), Lindh and Ohlsson (1996), Taylor (1996, 2001), Dunn and Holtz-Eakin (2000), and Johansson (2000).

endogeneity of the constraint and/or unobserved heterogeneity. Following empirical results that confirm the endogeneity of capital constraints, we employ an instrumental variable (IV) estimator to take account of this problem explicitly. Our analysis complements recent research by Hochguertel (2003) and Hurst and Lusardi (2004) who showed that financial wealth is endogenous in the context of occupational selection into entrepreneurship. Unlike those authors, we attempt to measure capital constraints directly, and generate IV estimates of their impact on the subsequent performance of entrepreneurs.

Our second contribution is to treat education as an additional endogenous variable that also helps to explain entrepreneurs' performance. Whereas the literature on returns to *employees*' human capital has recognised the endogeneity of human capital decisions (e.g., Ashenfelter *et al*, 1999), the literature on the returns to entrepreneurs' human capital has yet to do so (Van der Sluis *et al*, 2003). It is important to treat human capital as an endogenous variable if individuals accumulate human capital in anticipation of future performance, or again if unobserved heterogeneity is present in the human capital and performance equations. This is generally the case and turns out to be so in our application as well. Subject to some caveats about the available instruments, once again IV is used to provide consistent estimates of the impact of this variable on entrepreneurs' performance.

Our third contribution is to estimate the *combined* effects of education and capital constraints on performance, while controlling for a possible relationship between these explanatory variables. By disentangling the various inter-relationships, more reliable estimates of the determinants of entrepreneurial performance can be obtained.

The remainder of the paper is structured as follows. Section 2 presents a theoretical perspective on the issues. A theory of credit rationing recently proposed by Bernhardt (2000) is extended to encompass human capital and entrepreneurs' performance. Section 3 outlines the econometric issues and modelling strategy. Section 4 describes the data sample. Section 5 contains the estimation results, and Section 6 concludes.

2 Theory

If we are to understand the relationship between human capital, borrowing constraints, and entrepreneurs' performance, it is necessary to go beyond simply assuming the existence of constraints, as in e.g., Evans and Jovanovic (1989), and to ask why those constraints are there. This necessitates a foray into the theoretical literature on credit rationing. As Keeton (1979) and Jaffee and Stiglitz (1990) both pointed out, there are several distinct types of credit rationing. To be consistent with our empirical investigation, we shall confine our attention in this paper to rationing that takes the form of borrowers receiving smaller loans than they request from lenders. In Keeton's terminology, this is called 'Type I' credit rationing. For brevity, we shall not consider 'Type II' rationing, whereby some individuals receive no loan whatsoever, despite being observationally identical to others who do.

Our strategy is to take an existing model of Type I credit rationing, by Bernhardt (2000), and to extend it to deal with human capital and entrepreneurs' performance. We first briefly summarise Bernhardt's model, before discussing the extension.

2.1 Bernhardt's model

Bernhardt (2000) considered a problem with a single period planning horizon, at the start of which an investment project becomes available. Entrepreneurs have the skills to expedite the project but lack the capital, k, which they borrow from a bank. At the end of the period the project pays off $p.f(k)$, where $p > 0$ is a stochastic price with distribution function $G(p)$, whose support is the positive half-line; and where $f(\cdot)$ is a strictly concave production function. Entrepreneurs and lenders are risk-neutral and symmetrically uninformed about realisations of p *ex ante*. Lenders supply k via standard debt contracts which protect borrowers from negative net wealth, and lend at the competitive interest rate r. The risk-free gross interest rate is unity. If an entrepreneur defaults, the lender takes over the project and extracts all the revenues.

Entrepreneurs maximise expected profits, given by

$$\max_k E\{\max[0, pf(k) - rk]\}. \tag{1}$$

When choosing k, the entrepreneur is concerned only with positive profit realisations, so has the first order condition

$$\int_{p \geq p^*} [pf_k(k^*) - r]\, dG(p) = 0, \tag{2}$$

where p^* is the price at which the entrepreneur just begins to break even: i.e., $p^* f(k^*) - rk^* \equiv 0$; and where k^* denotes the privately optimal capital choice.

Bernhardt showed that, when there is a positive probability of default, k^* is not the same as the efficient level of investment, k^e. The first order condition for k^e is

$$\int_p pf_k(k^e)\, dG(p) \equiv \int_{p \geq p^*} pf_k(k^e)\, dG(p) + \int_{p < p^*} pf_k(k^e)\, dG(p) = 1. \tag{3}$$

The first order condition for k^* is different to (3), as can be seen by solving the lenders' break even condition $\int_{p<p^*} pf(k^*)\, dG(p) + \int_{p \geq p^*} rk^*\, dG(p) = k^*$ for the interest rate

$$r^* = \frac{k^* - \int_{p<p^*} pf(k^*)\, dG(p)}{k^* \int_{p \geq p^*} dG(p)}$$

and substituting it into (2) to obtain

$$\int_{p \geq p^*} p f_k(k^*)\, dG(p) + \int_{p<p^*} \frac{p f(k^*)}{k^*}\, dG(p) = 1\,. \tag{4}$$

Comparing (3) and (4), it follows that $k^* > k^e$ since $f(k)/k > f_k(k)$. The difference between (3) and (4) boils down to the smaller amount of revenue that lenders extract in the case of bankruptcy, relative to the non-default state. The difference comes about because, given the freedom to choose loan sizes, entrepreneurs facing price uncertainty optimally over-invest in k to maximise returns in good (high-p) states, since they do not care about returns in the bad (low-p, default) states. We call the ratio

$$\delta := 1 - (k^e/k^*) \in [0, 1] \tag{5}$$

the *extent of the borrowing constraint.*

Finally, Bernhardt showed that k^e actually prevails in a competitive equilibrium, together with an interest rate r^e, where

$$r^e = \frac{k^e \int_{p<p^*} p f(k^e)\, dG(p)}{k^e \int_{p \geq p^*} dG(p)} < r^*\,.$$

The reason why (k^e, r^e) is the equilibrium contract is that the total surplus is maximised with this outcome; and in a competitive lending market entrepreneurs receive all the surplus.

2.2 Extending the model by introducing heterogeneity

We now extend the model just described, by introducing heterogeneity into entrepreneurs' production sets. We assume that this takes the form of heterogeneous ability. Ability might be observable to lenders, as in the case of years of schooling, for example. Or it might be unobservable, as in the case of untried innate business acumen. In general, overall ability in entrepreneurship is likely to be a mix of both observed and unobserved components. To establish the main points, we will start by considering one aspect of ability, which is unobserved by both lenders and entrepreneurs. We then consider the implications of a different aspect of ability that is perfectly observable by both parties. Finally, we show how the insights from both investigations can be combined.

A Unobserved ability

Let x denote symmetrically unobserved ability. It is distributed unequally across the population of entrepreneurs. Each entrepreneur approaches one of an identical set of lenders, and undergoes a screening process designed to assess their unobserved ability. Lenders use a common screening technology to assess ability and classify entrepreneurs. The screening technology is unbiased on average, so lenders break even. But the technology is imperfect, being prone to errors that cause misclassification of some entrepreneurs. Because all lenders are identical, and use the same screening technology, they all make the same errors.

Greater x is associated with greater productivity. For example, consider generalising the production function of the previous sub-section to become $f(k, x)$, assumed to be increasing in both k and x. Clearly, both entrepreneurs and lenders benefit in expected value terms from higher x. So if entrepreneurs can be differentiated from each other, albeit imperfectly, separating contracts must emerge in equilibrium, whereby each x is associated with its own distinct borrowing class and equilibrium capital and interest rate tuple, $[k^e(x), r^e(x)]$, where $k^e(x)$ and $r^e(x)$ are increasing and decreasing functions of x, respectively.[2] Bernhardt's analysis can then be regarded as applying for the special case where all entrepreneurs have the same x and where screening is perfect. Note that the existence of observation errors arising from imperfect screening means that some individual entrepreneurs will receive different $[k^e(x), r^e(x)]$ contracts than they truly merit.

Proposition 1. *In the presence of screening errors, tighter borrowing constraints lead to lower average entrepreneurial profits.*

The logic of this proposition – whose proof together with those of subsequent propositions is relegated to Appendix A – is straightforward. Greater capital increases entrepreneurs' profits, even in the efficient equilibrium outcome. So entrepreneurs who are misclassified by lenders' screens either get more capital than they should, which relaxes their borrowing constraint and leads to higher profits, or they get too little, with the opposite effect.

B Observed ability

Now consider a different aspect of ability that is perfectly observed by both lenders and entrepreneurs. Henceforth we will think of this specifically as certified human capital (e.g., years of schooling), though other examples could no doubt also be proposed. Denote this aspect of ability by x_J, and again generalise the Bernhardt production function to become $f(k, x_J)$, with $f_k > 0$ and $f_{x_J} > 0$ as above. Also, it seems reasonable to assume that capital and human capital are complements, so f_{kx_J} is strictly positive if f is non-separable in the arguments (and of course is zero if f is separable). Now the first order condition of an entrepreneur with x_J changes from (2) to become

$$\int_{p \geq p^*(x_J)} \{p f_k[k^*(x_J), x_J] - r\} \, dG(p) = 0 \,, \tag{6}$$

[2] If instead x was private information of the entrepreneur, then perfect separation of types would generally be expected to occur because more able entrepreneurs would seek different sized loans and so reveal their types in that way (De Meza and Webb, 1992). However, it is arguably more realistic to treat innate business ability as unknown to entrepreneurs as well as to lenders.

where $k^*(x_J)$ is the solution of (6); and where

$$p^*(x_J) := \frac{rk^*(x_J)}{f[k^*(x_J), x_J]}$$

is the new break-even price. In a similar fashion, lenders' first order condition changes from (3) to become

$$\int_p pf_k[k^e(x_J), x_J]\, dG(p) = 1\,. \tag{7}$$

Proposition 2. *Greater human capital decreases borrowing constraints if entrepreneurs' production functions are separable in human and physical capital, and has ambiguous effects on borrowing constraints if entrepreneurs' production functions are non-separable in human and physical capital.*

The intuition behind Proposition 2 is as follows. With a non-separable production function, greater human capital increases the marginal product of capital and hence the average demand for capital. At the same time, the set of prices at which low levels of capital usage is profitable expands which serves to decrease the average demand for capital. Thus the first effect might be offset by the second. However, with a separable production function the first effect is no longer operative while the second is, leading to the result in the proposition.[3]

A prediction that greater human capital is associated with lower measured borrowing constraints can also be obtained using different arguments. For example, it is widely believed that entrepreneurs exhibit unrealistic over-optimism (De Meza and Southey, 1996; Manove and Padilla, 1999). So if better educated entrepreneurs are less over-optimistic than poorly educated entrepreneurs, and if the most over-optimistic entrepreneurs demand the most capital, then this also implies a negative relationship between human capital and borrowing constraints.[4]

Finally, we can derive our final proposition:

Proposition 3. *Greater human capital increases entrepreneurs' profits.*

C Summary

To summarise so far, we have established that symmetrically unobserved ability is associated with a negative relationship between profits and borrowing constraints, while symmetrically observed ability (e.g., in the form of human capital) has a positive impact on profits. Greater human capital has an ambiguous effect on borrowing constraints, though its effects are def-

[3] Similar results obtain if symmetrically observed ability enters entrepreneurs' cost (rather than production) functions in a separable or non-separable fashion.

[4] We are grateful to David de Meza for suggesting this possibility to us.

initely negative if entrepreneurs' production (or cost) functions are separable in ability and capital.

In general, ability might contain both observed and unobserved components. If so, all of the above results continue to apply. Propositions 2 and 3 remain relevant when making *between*-group comparisons of entrepreneurs. But *within* each and every group (e.g., for a performance model that conditions on observed ability such as human capital), imperfect screening of unobserved ability ensures that Proposition 1 continues to hold as well.

Finally, we say a word about the efficiency of borrowing constraints in this set-up. As in other models of Type I credit rationing, rationing in the Bernhardt model is efficient.[5] Thus, while entrepreneurs might complain that they would like more funds (k^*) than they actually receive (k^e) – and while relaxation of their borrowing constraint would certainly increase their profits (see Proposition 1 above) – it does not follow that any public intervention in the market is warranted. Furthermore, while errors in screening technologies do lead to inefficient outcomes, it does not follow that government intervention could practically improve matters here. Lenders presumably use the best screening technology available, and governments are unlikely to possess any information advantage over lenders in this respect, as would be required for successful public intervention.

Thus while the relationship between borrowing constraints and performance is of central policy interest, any empirical finding that tighter constraints decrease entrepreneurs' profits does not necessarily imply the existence of inefficiency or market failure. This is an important point that is sometimes overlooked in empirical research and the wider policy debate. Naturally, there are caveats to the generality of this conclusion. For example, suppose that entrepreneurship generates some valuable positive externality not considered in the model, for example a valuable innovation spillover. Then even 'efficient' borrowing constraints that decrease the equilibrium level of entrepreneurship might in principle motivate government intervention to relax them. This possibility should be borne in mind when interpreting the empirical results below.

3 Empirical methodology

In order to take data to the three propositions of the previous section, we develop an empirical model that simultaneously estimates the effects of human capital and capital constraints on performance, as well as the relationship between human capital and capital constraints. For reasons explained below, we will discuss human capital in terms of education, measured as years of schooling; other human capital variables such as labour market experience, are included as exogenous variables.

[5] Other models of Type I credit rationing that share this feature include Keeton (1979), Clemenz (1986), de Meza and Webb (1992), and Canning *et al* (2003). In contrast, Type II rationing is usually associated with efficiency losses. See, e.g., Stiglitz and Weiss (1981) and Parker (2003).

Consider first the effect of education on the performance of entrepreneurs. There are at least two possible sources of bias if OLS is used to estimate this relationship. First, the schooling decision is probably endogenous in a performance equation because individuals are likely to base their schooling investment decision, at least in part, on their perceptions of the expected payoffs to their investment. Second, there may be unobserved individual characteristics, such as ability and motivation, that affect both the schooling level attained and subsequent business performance. The omission of these unobserved characteristics from a performance equation would also serve to bias OLS estimates, where the direction and magnitude of the bias depends on the correlation between these characteristics and the schooling level attained. For example, consider the simple linear model

$$y = \beta_0 + \beta_1 x_1 + \cdots + \beta_{J-1} x_{J-1} + \beta_J x_J + u\,, \tag{8}$$

where y denotes entrepreneurial performance, x_1 through x_{J-1} are exogenous variables (including past experience), and x_J denotes years of schooling, where $E(u) = 0$ and $\text{cov}(x_j, u) = 0$ for $j = 1, 2, \ldots, J-1$ but where x_J might be correlated with the disturbance term u. In other words, the explanatory variables $x_1, \ldots, x_{J-1}$ are exogenous, but x_J is potentially endogenous for the reasons explained above.

Instrumental Variables (IV) is known to be an appropriate estimator in the presence of these problems (see Card, 1999, 2001; Ashenfelter *et al*, 1999). Most of these researchers have concluded that OLS estimates of the return to schooling are biased downwards. Their focus, however, has invariably been the measurement of the returns to schooling in *wage employment*. In contrast, we do not know of any IV estimates of returns to schooling for *entrepreneurs*.[6] The IV approach (see Wooldridge, 2002) exploits the existence of an *identifying* instrument, possibly a vector, z_1, not in (8) that satisfies two conditions: (i) $\text{cov}(z_1, u) = 0$ and (ii) $\theta_1 \neq 0$ in the reduced form equation for the endogenous explanatory variable x_J:

$$x_J = \eta_0 + \eta_1 x_1 + \cdots + \eta_{J-1} x_{J-1} + \theta_1 z_1 + v\,, \tag{9}$$

where $E(v) = 0$ and where v is uncorrelated with the x_j ($j = 1, \ldots, J-1$) and z_1. Condition (i) above relates to the *validity* of the (identifying) instrument(s); condition (ii) relates to the *quality* of the instruments.

The next issue is the financial constraints experienced by entrepreneurs when they set up their businesses. According to Proposition 1 above, such constraints will affect entrepreneurs' performance. So if we denote a measure of these constraints (whose definition is discussed in the next section) by x_{J+1}, then this variable should also be added to the right hand side of (8). Again, however, one must acknowledge the possibility that this explanatory variable is endogenous. After all, it is to be expected that both actual and desired amounts of start-up

[6] Van der Sluis *et al* (2004) are an (as yet unpublished) exception.

capital will be positively related to the prospect of high business performance. And there might also be unobserved individual characteristics, such as ability and motivation, that affect both the extent of capital constraints (for instance via banks' loan application selection procedures) and subsequent business performance.

Therefore, we incorporate x_{J+1} into an empirical model in the same fashion as the schooling variable, using an IV approach. Accordingly, this leads to a second reduced form equation:

$$x_{J+1} = \gamma_0 + \gamma_1 x_1 + \cdots + \gamma_{J-1} x_{J-1} + \gamma_J x_J + \theta_2 z_2 + \omega \,, \tag{10}$$

where $E(\omega) = 0$, z_2 is the identifying instrument(s) for capital constraints, and θ_2 is its estimated coefficient(s), satisfying the same conditions (i) and (ii) of validity and quality as should hold for z_1 and θ_1. This equation also generates a consistent estimate of the effect of schooling, x_J, on capital constraints. The final version of the structural performance equation (8) is therefore

$$y = \beta_0 + \beta_1 x_1 + \cdots + \beta_{J-1} x_{J-1} + \beta_J x_J + \beta_{J+1} x_{J+1} + u \,. \tag{11}$$

Schooling x_J is taken to be exogenous in (10). The theoretical case for endogeneity is weaker in the capital constraint context because it seems unlikely (although possible) that individuals acquire schooling in order to bypass capital constraints that they might encounter in the future. Although the problem of unobserved heterogeneity in both equations is perhaps a more plausible reason, in fact we found no empirical support for this possibility when we tested for it, as discussed below. This endows the model with the 'endogenous triangle' structure (between human capital, capital constraints and performance) illustrated in Figure 1.

[INSERT FIGURE 1 AROUND HERE]

The parameters of the structural performance equation (11) and the reduced forms for x_J and x_{J+1} can be estimated by 2SLS. This renders consistent estimates of the parameters of interest, namely β_J, β_{J+1} and γ_J, so that the three propositions of Section 2 can be tested. In short, Propositions 1 through 3 suggest the following parameter restrictions: $\beta_{J+1} < 0$, $\gamma_J \gtrless 0$, and $\beta_J > 0$ respectively – with $\gamma_J < 0$ under the separability assumption discussed earlier.

4 Data

The data set used in our empirical application is a random cross-section sample of Dutch entrepreneurs. Entrepreneurs were defined as individuals who started their own business from scratch or who took over an existing business. Our focus is therefore on individuals who start up rather than firms that do. The sample was generated as part of a public-private joint venture executed by the University of Amsterdam, the Erasmus University of Rotterdam, and the GfK market research company. It was commissioned by RABO, a large Dutch co-operative Bank, and the General Advisory Council of the Dutch Government. The data set contains a wide range of economic and demographic variables including ones relating to human capital, financial capital, and business performance. A unique aspect of the data set is its detailed coverage of start-up finance information, necessary for the construction of a continuous capital constraint variable, together with personal characteristics of the entrepreneur dated back to the time of start-up and earlier. A data appendix (Appendix B) provides additional details about variables contained in the data set.

In fall 1994, a questionnaire was sent to 1069 entrepreneurs who had already indicated their willingness to participate in the research. Of these, 709 responded. Of these, 125 respondents did not provide enough information to construct a measure of capital constraints; and of the remaining 584, 123 did not provide information about their income. That left 461 valid observations (including one female outlier, subsequently deleted, whose start-up capital was more than 15 standard deviations larger than the mean) which were compiled in 1995. As documented in Brouwer *et al* (1996), the sample is broadly representative of the Dutch population of entrepreneurs in terms of industry, company size, legal form, and age of companies and entrepreneurs. The sample contains a slightly larger proportion of highly educated respondents than is found in the general Dutch population, reflecting the fact that one of the commissioners of the research project (the General Advisory Council of the Dutch Government) was particularly interested in the determinants of performance and capital constraints among highly educated individuals. However, this is unlikely to carry any implications for measured rates of return to entrepreneurship in this study, as we found little evidence that rates of return vary systematically with years of education (see below for further details). Also, while we could not check whether our sample is representative in terms of average business income, as this variable is so definition-specific (see below), there is no reason to suppose that entrepreneurs who benefit more from an additional year of schooling will be any more inclined to respond than are entrepreneurs who benefit less from a marginal year of schooling. Summary statistics of the sample are given in Table 1.[7]

In order to define clearly our measures of entrepreneurial performance, human capital and financial constraints – and also to provide explicit linkage between the theoretical analysis and empirical specification – we next describe the key variables of interest. Particular attention is paid to the constraint variable, which we believe is a novel one that improves over other measures utilised in the literature to date.

4.1 Endogenous variables

Entrepreneurial performance (y) is measured as the natural log of 1 plus total gross annual business income from the venture in 1994 Dutch guilders (1.85 guilders = one US dollar in

[7] The data are freely available from the authors on request.

Table 1: Summary statistics of the variables used in the model

	N	Mean	St. Dev.	min.	max.
Endogenous Variables					
Annual 1994 log income (y)	460	3.54	1.50	0.00	6.62
Years of schooling (x_J)	455	14.78	3.18	6.00	18.00
Capital constraint % (x_{J+1})	460	19.01	30.07	0.00	100.00
Exogenous Variables					
No. siblings (x_1)	460	3.10	2.40	0.00	13.00
Current age (x_2)	453	40.43	10.63	21.00	62.00
Father's education (x_3)	442	11.60	3.66	6.00	18.00
Female (x_4)	460	0.15			
Initial human capital					
Age (x_5)	450	33.32	8.42	14.75	59.17
Years general exp. (x_6)	448	10.11	8.69	0.00	46.00
Years industry exp. (x_7)	460	4.49	6.53	0.00	34.00
Has prev. business exp. (x_8)	460	0.15			
Switched from PE (x_9)	460	0.57			
Initial financial factors					
Earned wage at start (x_{10})	460	0.26			
Partner had suff. income (x_{11})	460	0.17			
Personal equity (x_{12})	447	20.91	45.05	0.00	500.00
Capital required (x_{13})	460	65.33	119.16	1.00	800.00
Additional controls (y eq.)					
Capital intensive industry(x_{14})	460	0.13			
Current firm age in years (x_{15})	457	7.11	8.16	0.50	40.50
Current no. employees (x_{16})	423	5.06	17.39	1.00	300.00
Weekly hours at start-up (x_{17})	441	51.69	20.23	2.00	100.00
Current spouse input (x_{18})	460	0.25			

Notes: Standard deviations, minimum and maximum values are omitted for dummy variables. N is the number of valid observations. This can be less than 460 because non-responses or missing observations vary according to the question asked. Income is measured in thousands of Dutch guilders in 1994 prices, with mean 70.45 (St. Dev.=79.32). PE is paid employment. For the detailed definition of variables, see text.

1994). Business income is defined as all income from the business before deducting tax and social security contributions but after deducting business related costs. Hence this variable approximates personal income from the business, consistent with the discussion in Section 2.[8] As a comprehensive measure of income, it includes wages paid to entrepreneurs as well as returns to capital. In an attempt to control for the latter, all performance regressions are reported including controls for capital required and personal equity invested in the business.[9] An advantage of using log income as a measure of performance is that it facilitates a comparison of the returns to education from the literature on employee earnings functions.[10]

The second endogenous variable is human capital (x_J). The aspect of human capital that we focus on here is education. It was felt that trying to endogenise additional dimensions of human capital, such as years of experience, would entail too many theoretical and empirical complexities, which go beyond the scope of this paper. We measure education as the number of years of schooling rather than the highest schooling level attained.

The third endogenous variable is *capital constraints*. This is a more broadly defined variable than *borrowing constraints* because unlike the latter, capital constraints also take into account the possibility that some individuals use their own personal equity to fund their start-ups, either in part or in whole. The theoretical analysis in Section 2 abstracted from this issue. In fact, personal equity is widespread in our sample. 81 per cent of respondents injected at least 1000 guilders of own savings into their business, and 66 per cent at least 3000 guilders.

The theoretical model is easily extended to deal with personal equity. Reflecting banking practice in the Netherlands (and many other countries), entrepreneurs first declare to the lender their investment of personal equity in the business, denoted by A; and request their desired amount of borrowing k^* given A. As the next step, the lender conditions their loan on the basis of the available information (including A) and offers k^e. All entrepreneurs with the same personal equity and observable characteristics should experience the same Type I rationing, with $k^* < k^e$ for the reasons given before.

To construct a measure of capital constraints, we take note of two issues: multiple lenders and the need to control for personal equity as a source of finance which might dilute borrowing constraints. First, we measure k^e to allow for loans from possibly multiple lenders. Our data on capital borrowed from lenders is not restricted to bank borrowing (though we counted

8Every respondent was assured of anonymity by the survey interviewers. For those running businesses jointly with their spouse, joint income was reported; we control for this below by including a dummy variable for input into the business by a spouse or partner.

9We also tried including controls for whether the business was incorporated, as incorporated firms pay their directors an 'employee' wage; but this also proved to be insignificant.

10Unfortunately, the sample surveyors converted any negative incomes to zero. There were 28 cases with zeros, which include 'genuine' zeros as well as converted cases. All of these are included in the sample since y is defined as $\ln(1 + \text{income})$. Clearly, this treatment of negative incomes biases average measured performance above the 'true' level. However, an attempt to deal with this using a tobit estimator suggests that it probably has little impact on our results. Estimating performance models by tobit changed the constant term slightly, but otherwise the coefficient estimates were more or less unchanged, including the return to education. We do not report those results below for brevity.

only business loans and not consumer loans). To be consistent with the theoretical analysis, which applies to any kind of borrowing, we used sample data on several finance sources to compute the total amount borrowed. These include banks, venture capitalists, government loan agencies, and trade credit. Of these, banks were the most commonly used source of finance, by one third of all respondents in the sample. Second, define K^e and K^* as the total amounts of capital used and required (rather than borrowed), respectively, where $K^e = A + k^e$ and $K^* = A + k^*$. Now analogous to (5), the extent to which an individual is *capital constrained* can be measured as

$$\Delta := 1 - \frac{K^e}{K^*} = 1 - \frac{k^e + A}{k^* + A} \quad \in [0, 1]. \tag{12}$$

Because every term in (12) is measurable, Δ forms the basis of our empirical measure of capital constraints.[11] As can be seen by differentiating Δ and δ with respect to k^e and k^*, Δ possesses the same properties as δ, in the sense that Propositions 1, 2 and 3 of the previous section all continue to apply.[12]

In our empirical work we will work with the scaled capital constraint variable $x_{J+1} := 100.\Delta$. Arguably, x_{J+1} captures more precisely the notion of *constraints* than do *measures of financial capital* used in many previous studies, such as savings, assets, inheritances, or lottery outcomes (see the studies referenced in footnote 1).[13] Another advantage of x_{J+1} is that it is a continuous variable. In general it will therefore possess greater information content than dummy variables (used by, e.g., Astebro and Bernhardt, 2003) that indicate whether an entrepreneur believes herself to be credit constrained.

One drawback of x_{J+1} is that it is based on self-reported data. Individuals might give biased estimates of their required and actual initial capital values (a problem that might also be shared by some previous empirical studies utilising self-reported asset values). On the other hand, entrepreneurs might exaggerate capital requirements when approaching lenders, as a negotiating tactic. If so, then at least it seems plausible that responses obtained from an anonymous questionnaire, as in the sample used here, will be more accurate than those obtained from bank file data.

[11] In particular, values of K^* were given as responses to the questionnaire question 'How much capital did you need at the start of your current business?', and those of K^e as responses to the question 'What was the amount of money that you actually started with?' It was clear from the survey question that loans were for business purposes rather than for personal consumption use. Values of A were given as responses to the question 'How much of your own money did you invest in the company at the start?'

[12] Note however that because $\partial\Delta/\partial A < 0$ and given that $A \geq 0$ by definition, it follows that $\Delta \leq \delta$. This implies a weaker (empirical) relationship between performance and capital constraints than between performance and borrowing constraints in Proposition 1.

[13] Previous empirical research suggests a positive relationship between financial *capital* and entrepreneurial performance. But these studies do not measure capital requirements at all, so such a relationship is not necessarily indicative of capital constraints. For example, the observed empirical relationship might simply reflect decreasing absolute risk aversion (Cressy, 2000), or a positive competition externality (Black *et al*, 1996). Furthermore, recent research (Hochguertel, 2003; Hurst and Lusardi, 2004) casts doubt on the robustness of this relationship.

Finally, it is worth pointing out that the institutional framework in the Netherlands corresponds to that assumed in the theory in two important respects. First, personal equity is indeed usually contracted with the bank upfront in the Netherlands, as we assumed. Second, once creditors have exercised their claims on a bankrupt's assets, the latter faces no future income garnishing, so entrepreneurs do indeed face a personal lower bound of zero net wealth (see, e.g., (1)).

4.2 Exogenous variables

The endogenous variables are not only related to each other, as already discussed, but may also depend on exogenous variables.

Several exogenous variables are likely to affect choices of education, and in particular the decision to pursue a specific number of years of formal schooling. These include early childhood factors such as number of siblings, current age (capturing cohort effects), the father's education level, and gender.

As well as (endogenous) years of schooling, several exogenous *initial human capital* variables (i.e., dated from the year in which entrepreneurial ventures were started) are likely to affect the extent of capital constraints and incomes. These include the entrepreneur's gender, the number of years of work experience (both general and in the same industry), whether the entrepreneur had previous business experience, and whether they switched from paid employment, PE, (in the public or private sector) just prior to start-up.[14] We expect all of these variables to be positively associated with subsequent performance (because human capital is valuable) and negatively associated with capital constraints — e.g., because lenders use them as favourable indicators of ability and creditworthiness (see Section 2.2).

Income and capital constraints might also be affected by entrepreneurs' *initial financial* circumstances. For example, consider an entrepreneur who continued to receive some wage income at the time of start-up, or who had a spouse or partner that earned sufficient income at that time for the venture to survive poor performance (we allow here effects that depend on gender). Such 'external' (i.e., non-entrepreneurial) income sources can be expected to relax an entrepreneur's capital constraint. Their effects on performance might go either way, however.[15] From (12), the extent of capital constraints is a decreasing function of personal equity, A, and an increasing function of total capital required, K^*. But both variables might

[14] The last of these dummy variables takes the value zero for 43 per cent of the entrepreneurs. This comprises self-employed (9 per cent), students (13 per cent), unemployed (16 per cent), or otherwise classified (5 per cent).

[15] On the one hand, by decreasing the variability of household resources, extra income sources might permit the entrepreneur to choose a project occupying a higher point on the risk-return trade-off. On the other hand, extra sources of income might distract the entrepreneur's attention from running the core business. In the case of additional income from wages, the entrepreneur is presumably diverting some effort directly from the business to paid employment. In the case of having a working spouse, the entrepreneur might be required to contribute more time to household production, and so less to the business, than would otherwise be the case.

have additional effects by affecting also capital obtained from lenders. For example, lenders frequently value injections of personal equity as collateral since that can make an entire loan relatively safe from their perspective. The opposite is the case with regard to the size of the loan itself. To avoid complications caused by (arbitrary) specifications of non-linear functional forms, but to nonetheless capture the main idea, we enter both of these variables (which are measured at the time of start-up) in the capital constraint and performance equations both in levels and squares. Furthermore, in the capital constraints equation, we also control for the capital intensity of the industry in which the entrepreneur starts her venture. We would expect start-ups in capital intensive industries to have a greater likelihood of being capital constrained, if banks' screening errors are systematically greater in industries where more complicated production techniques (and possibly also complementary intangible capital) are used.

Other control variables that are likely to affect entrepreneurs' current performance include the current age of the firm; current firm size (measured by the number of full-time equivalent employees, including the entrepreneur himself); and the average weekly number of hours worked in the first year of the venture. None of these control variables are expected to influence years of schooling or capital constraints.[16]

5 Results

This section is divided into four parts. In the first, we demonstrate the importance of treating years of schooling and capital constraints as endogenous variables. We also obtain empirical backing for the 'endogenous triangle' structure of our model and discuss our choice of instruments. In the remaining parts, we present and interpret the schooling, capital constraint, and performance equations.

5.1 Endogeneity issues

It has been suggested that both years of schooling and capital constraints are likely to be endogenous variables in the entrepreneurial performance equation, while schooling is less likely to be endogenous in the capital constraint equation. We can test directly the *relevance* of correcting for endogeneity in each of these three cases by applying Hausman's (1978) t test. The validity of Hausman's test depends on the underlying choice of identifying instruments satisfying quality and validity criteria, tests of which also appear below.

[16] Work hours in the first year of a venture should be exogenous in a performance equation estimated using data on firms over a year old. There were 7 observations in the sample with ventures less than a year old at the date of interview. While it is possible that effort might be endogenous for these cases, the results were virtually unchanged when these observations were excluded from the sample. In addition, we found no evidence of endogeneity of firm age and size with respect to performance. Note also that work effort (hours) at the time of start-up is generally regarded as non-verifiable and non-contractible in games of start-up finance (Boot and Thakor, 1994).

The identifying instruments used in the schooling equation (9) are the respondent's father's education and the number of siblings in the respondent's family. These are common though not undisputed choices in the returns to schooling literature (see, e.g., Blackburn and Neumark, 1993, 1995). While some other authors (e.g., Harmon and Walker, 1995; Acemoglu and Angrist, 1999) have sought identification in terms of regional and legal variations in education, these sources of variation are themselves not immune to criticism (Card, 2001) and are in any case unavailable in the Netherlands. Therefore we proceed cautiously using our instruments, further discussion of which appears below. They are supplemented by controls for age and its square (capturing possible cohort effects), and gender.

Finding valid identifying instruments for the capital constraint equation (10) requires isolating variables that affect these constraints without impacting directly on performance. Recall that the model hypothesised screening errors as the principal reason for a relationship between performance and capital constraints. It seems plausible that bank screening errors, and hence the incidence of capital constraints, will be greater in more capital-intensive industries where production processes are more complex, and where the amount of intangible capital might also be greater. Evidence from investments in computers, for example, indicates strong complementarity between tangible and intangible investment (Brynjolfsson and Yang, 1999; Brynjolfsson and Hitt, 2003). In a similar vein to Hurst and Lusardi (2004), we therefore propose as an identifying instrument an indicator variable for whether the industry is capital-intensive or not. We define the following industries as capital intensive: industrial, production, construction, and transportation. Note that there is no necessary reason why capital intensiveness should impact on performance, a conjecture that is borne out by a validity test described shortly. Alternative possible candidates for the set of identifying instruments will be discussed below together with the control variables included in the capital constraint equation.

Row 1 of Table 2 presents the Hausman tests for endogeneity. The significance of the statistics given in the first and third columns suggests that years of schooling and capital constraints are indeed endogenous in the entrepreneurial performance equation. The insignificance of the statistic in the second column implies that years of schooling can indeed be treated as exogenous in the capital constraint equation, justifying the triangular structure of our model.

We now test whether the proposed identifying instruments are of high *quality* and are also *valid*. Following Bound *et al* (1995), the quality of the instrument set can be gauged by F statistics that test the null hypothesis of insignificant instruments θ_1 and θ_2 in (9) and (10), respectively. Row 2 of Table 2 presents the test statistics for the quality of the identifying instruments for years of schooling (9) and capital constraints (10) (columns 1 and 2 are identical because they both relate to (9)). The significance of these 'partial F' statistics suggests that the proposed identifying instruments are indeed of high quality in both cases.

Instruments are valid if they affect performance via the instrument equation (9) or (10)

Table 2: Diagnostic tests of instrument relevance, quality, and validity

Variables:	Schooling		Cap. Con.
Tests	Performance eq.	Cap. Con. eq.	Performance eq.
Relevance	$t_{349} = -1.73$	$t_{392} = 0.76$	$t_{392} = 2.19$
	[0.09]	[0.45]	[0.03]
Quality	$F(2, 427) = 29.71$	$F(2, 427) = 29.71$	$F(1, 407) = 4.25$
	[0.00]	[0.00]	[0.04]
Validity	$F(20, 349) = 0.01$	$F(16, 393) = 0.02$	$F(19, 364) = 0.00$
	[1.00]	[1.00]	[0.83]

Each cell gives the diagnostic test result with p-values in square brackets. The 'Relevance', 'Quality' and 'Validity' tests are defined in the text.

only. Sargan's F statistic (Davidson and MacKinnon, 1993) tests the null hypothesis that the identifying instruments are orthogonal to the error of the IV equation. Row 3 of Table 2 shows that the instruments sets proposed for equations (9) or (10) are indeed valid. The result for years of schooling vis-à-vis the performance equation is especially reassuring because it counters the criticism that family background variables might be invalid instruments because they are correlated with unobserved ability and thereby affect entrepreneurs' performance (see Card, 1999, 2001, for a discussion).

5.2 Explaining the schooling decision

The first column of Table 3 presents estimates of the schooling equation (9). Both this equation and the capital constraints equation discussed shortly contain a mixture of controls and identifying instruments. Both of the identifying instruments 'Number of siblings' and 'Father's education' are statistically significant determinants of years of education; and the regression as a whole is also significant [$F(6, 428) = 41.74$]. Individuals born in families whose fathers are better educated, and where there are fewer siblings to compete for attention and resources, tend to acquire significantly more education than the average. Of the two identifying instruments, father's education is the more powerful, since while the results were unchanged by dropping the number of siblings, the predictive power of the number of siblings on its own was too low to estimate precisely the effect of schooling on performance.[17] We therefore proceed using both identifying instruments.

[17] Full details are available from the authors on request. We also tried alternative identifying instruments based on religious affiliation of schools and the birth month of the respondent, but neither of these variables were statistically significant.

Table 3: Estimates of the schooling and capital constraint equations

	Schooling eqn. (9)		Capital con. eqn. (10)	
Variable	Coeff.	t-ratio	Coeff.	t-ratio
Years of schooling			-1.183^{**}	2.20
No. siblings	-0.178^{***}	2.71		
Current age	0.292^{**}	2.50		
Current age squared	-0.004^{***}	3.15		
Father's education	0.276^{***}	7.42		
Female	-0.780^{**}	2.25	-0.835	0.17
Female × Partner suff. inc.			-18.028^{**}	2.15
Partner suff. inc.			8.778	1.77
Age at start-up			0.295	0.23
Age at start-up squared			-0.007	0.38
Years general exp.			0.218	0.68
Years ind. exp.			-0.386	1.60
Has prev. bus. exp.			5.439	1.29
Switched from PE			-9.360^{***}	3.00
Earned wage at start			0.954	0.29
Personal equity			-0.343^{***}	5.03
Pers. equity squared			0.001^{***}	3.88
Capital required			0.136^{***}	3.32
Cap. required squared			-0.0001^{***}	2.96
Cap. intensive industry			8.723^{**}	2.06
Intercept	8.216^{***}	3.54	36.654	1.54
R^2	0.31		0.13	
$F(k, n-k)$	41.74^{***}		4.98^{***}	
No. Observations, n	433		424	

Notes

Dependent variables are defined in the text. Regressions reported with robust standard errors. $^{**}p$-value less than 0.05; $^{***}p$-value less than 0.01. k is the number of parameters and $n-k$ is the degrees of freedom. The sample size reduces to 433 in the schooling equation because of the 460 initial observations, 7, 5 and 15 observations were missing for "Age at start-up", "Years of education", and "Father's education", respectively. The sample size is 424 in the capital constraints equation because of missing data on these and some additional explanatory variables (precise details available on request).

Our findings are similar to those of Van der Sluis *et al* (2004) for entrepreneurs, and of Blackburn and Neumark (1993) and Levin and Plug (1999) for employees. We also find that females obtain significantly less education than average, and there also seems to be a cohort effect at work, whereby older respondents obtained more education than younger respondents. Overall, the respectable fit attained by this regression ($R^2 = 0.31$) suggests that it forms a reasonable basis for estimating the impact of education on entrepreneurial performance. We do however acknowledge the limitations of the available instruments used in this regression.

5.3 Explaining the extent of entrepreneurs' capital constraints

The final column of Table 3 presents estimates of the capital constraint equation (10). The key result is that extra years of schooling significantly decrease capital constraints. The estimated coefficient is large in absolute terms and statistically significant with a p-value of 2.8 per cent. This result, which implies that an extra year of schooling relaxes the capital constraint by 1.183 per cent, is consistent with Proposition 2 (and separable entrepreneurial production functions). It implies that lenders are more willing to provide funds to better-educated entrepreneurs, all else equal.

In addition, we find that entrepreneurs located in capital intensive industries are significantly more likely to face capital constraints than those located in industries where less capital is needed. This effect is additional to a scale effect from required capital, and so is consistent with a theoretical argument that banks' screening errors are systematically greater in some industries where more complicated production techniques with complementary intangible capital are used.

It is also of interest to interpret the other coefficients of Table 3. Women whose partners had sufficient income to support the household at the time of start-up face lower capital constraints, presumably because they can obtain resources from their partners. A similar mechanism was not observed for men. This was the only significant difference in capital constraints by gender, as gender interactions with the other variables failed to achieve significance. Another characteristic that appears to mitigate capital constraints is having switched into entrepreneurship from paid employment just prior to start-up. Such experience might serve as a positive signal to lenders, thereby encouraging them to offer more finance. As expected, the amount of personal equity injected at the start has a strongly negative and non-linear effect on the extent of capital constraints. The absolute size of this effect decreases as the amount of private business capital increases. The effect of the total amount of capital required by an entrepreneur on the extent of capital constraints is significantly positive, and also has a decreasing marginal effect. This might reflect lenders' unwillingness to over-extend themselves on risky investment projects. Over 97 per cent of respondents have net negative effects from effects from personal equity and net positive effects from capital required.

Every other variable in Table 3 is statistically insignificant. The R^2 of 13 per cent indicates that we have had only limited success in explaining the extent of capital constraints.[18] We also found no evidence that entrepreneurs with greater collateral other than personal equity faced lower capital constraints. While the data set does not contain information on collateral directly, it contains responses to two related questions: whether individuals raised finance by releasing equity from their houses, and whether they took over their firm (in which case they may have tangible collateral in place) or started it from scratch. Neither variable significantly decreased capital constraints. Neither an indicator variable of whether entrepreneurs took over a firm from family members, nor a dummy variable indicating access to loans at subsidised rates, were significant. The latter included funds obtained from family, friends, government programmes and business partners (detailed results are available from the authors on request).

5.4 Explaining entrepreneurs' performance

We now present results from estimating eq. (11), i.e., the determinants of entrepreneurs' performance. We present results – summarised in Table 4 – using both OLS and IV estimators. It will be seen how this comparison underlines the practical importance of correcting for endogeneity biases when attempting to explain entrepreneurs' performance.

[18] This low R^2 is certainly consistent with our earlier assumptions of unobserved ability and lender screening errors that led to Proposition 1. No doubt the poor fit in Table 3 might also provide encouragement to those who argue that many bank decisions on offering start-up finance are arbitrary, and based predominantly on intangible factors like 'first impressions' and prejudice rather than tangible observable characteristics. However, this conclusion must be tempered to the extent that our specification suffers from omitted variable bias. In fact, our data set contains detailed personal and financial information that encompasses what is typically found in bank file data (c.f. Cressy, 1993); and checks confirmed that none of these extra variables were significant in the capital constraint equation. (These variables included the legal form and structure of the start-up; detailed questions about the extent to which the individual was familiar with the relevant business environment; and detailed additional questions about job histories and family background.) Nevertheless, *verbal*, unrecorded information conveyed in bank interviews might also be playing a role. Finally, the possibility of mis-specification in this equation justifies our use of single equation estimators rather than a systems estimator like 3SLS or FIML. It is well known that any mis-specification of one equation in a system contaminates the estimates in every other equation – a criticism that does not apply to single equation estimators such as 2SLS used here.

Table 4: Estimates of the enterprise performance equation

	Performance eqn. OLS		Performance eqn. IV	
Variable	Coeff.	t-ratio	Coeff.	t-ratio
Years of schooling	0.072**	2.45	0.137**	2.01
Capital constraint	−0.003	1.14	−0.039**	2.23
Current age	0.214***	3.24	0.188***	2.67
Current age squared	−0.003***	3.91	−0.003***	3.10
Female	−0.507	1.86	−0.533	1.95
Years general exp.	0.054***	2.69	0.058***	2.79
Years ind. exp.	0.012	0.86	0.005	0.35
Has prev. bus. exp.	0.251	1.27	0.388	1.83
Switched from PE	0.414***	2.66	0.137	0.61
Earned wage at start	−0.239	1.54	−0.258	1.66
Female × Partner suff. inc.	0.737	1.78	0.111	0.22
Partner had suff. inc.	−0.280	1.20	0.023	0.09
Firm age	0.089***	4.22	0.092***	4.15
No. employees	0.010***	2.70	0.011***	2.99
Weekly hours at start	0.014***	3.71	0.014***	3.61
Spouse input	0.424**	2.46	0.442***	2.62
Personal equity	0.002	0.42	−0.011	1.61
Pers. equity squared	−0.000	0.10	0.000	1.57
Capital required	0.0002	0.10	0.005	1.69
Cap. req'd squared	−0.000	0.19	−0.000	1.56
Intercept	−2.748**	2.13	−2.575	1.66
R^2	0.27		0.28	
$F(20, n-21)$	8.65***		9.10***	
No. Observations, n	380		370	

Notes

Dependent variable: Log business income. Regressions reported with robust standard errors. Asterisks as in Table 3. Method of estimation is given at the head of the table. The sample size reduces to 370 for the IV results because of the 424 observations used in the capital constraint instrumented equation, 33, 11 and 10 observations were missing for "No. employees", "Weekly hours at start", and "Father's education", respectively. It is 380 for OLS because the absence of instrumentation avoided the need to discard 10 of these observations.

A Entrepreneurs' returns to schooling

The first column of Table 4 shows the (biased) estimation results that ensue when estimating (11) by means of OLS. It reports an average rate of return to schooling of 7.2 per cent in terms of entrepreneurs' gross incomes, supporting Proposition 3. A comparison with other OLS estimates of the return to schooling in entrepreneurship reveals that this estimate is a little higher than, but broadly comparable with, previous findings. For example, in a survey of 21 previous studies of the relationship between education and entrepreneurial earnings, Van der Sluis *et al* (2003) reported an average rate of return of 6.1 per cent for studies based on US data, with a somewhat lower average rate of return for European studies.

The second column of Table 4 presents the results using IV estimation. Like previous comparisons between IV and OLS conducted for employees, the IV estimate is substantially higher than the OLS estimate, being 13.7 per cent compared with 7.2 per cent.[19] The IV estimate of the rate of return to schooling is also precisely estimated, and still supports Proposition 3. It is somewhat higher than IV estimates for employees in similar countries. For example, Ashenfelter *et al* (1999) reported an average IV rate of return for employees of 9.3 per cent.

Such comparisons are of intrinsic interest for at least two reasons. First, they might carry policy implications for programmes designed to encourage high school and college graduates to become entrepreneurs. In the case of the estimates above, for example, they might help justify public expenditure on such programmes. Of course, this interpretation is subject to the earlier caveat that our results are only as good as the instruments they rely on, and in the case of years of schooling in particular these are not beyond reproach.

Second, entrepreneurs' rate of return to education bears on a long-standing question about whether rates of return to schooling for employees contain a signalling component (Wolpin, 1977). For example, it is sometimes argued that because only employees need to signal abilities to employers, they will earn higher average returns on their investment than entrepreneurs if

[19] See, e.g., Ashenfelter *et al* (1999), whose average IV estimates were nearly 3 per cent higher than their OLS estimates. Harmon and Walker (1995) and Lemieux and Card (1998) recorded even larger differences between IV and OLS. Card (2001) proposed an explanation for this phenomenon based on the hypothesis that the return to education is heterogeneous and declines at higher levels of education. IV estimates will differ from OLS estimates to the extent that the instruments influence schooling decisions at different levels. If the instruments influence decisions primarily at lower levels of education, then the IV estimate may be higher than the OLS estimate if it reflects the payoff to schooling at lower rather than higher levels of education.

the marginal productive effects of their education pursued are equal (Riley, 1979, 2002). Also, entrepreneurial success is likely to depend on numerous factors other than formal education, again implying that entrepreneurs will obtain a lower return to schooling than employees. On the other hand, entrepreneurs might invest in education as a hedge, or in order to work for others before commencing a spell in entrepreneurship. And customers, suppliers of credit, and government agencies might also screen entrepreneurs, especially in those industries in which the incidence of self-employment has grown rapidly in recent years, such as professional services. The available evidence certainly does not support the notion that entrepreneurs receive lower returns to education than wage employees do; but we are unable to shed any more light directly on this issue because our data set is limited to entrepreneurs. We will explore below whether the indirect effect of education on performance, via its impact on the capital constraint, increases further the total impact of years of schooling on entrepreneurs' business incomes.

B The role of capital constraints

The first column of Table 4 shows that the (biased) estimate of the effect of capital constraints on entrepreneurs' business incomes is numerically small, and statistically insignificant. However, the IV estimate given in the second column is over 10 times larger and highly significant. It implies that a 1 percentage point relaxation of capital constraints increases entrepreneurs' average business incomes by 3.9 per cent. This finding strongly supports Proposition 1.

The size of this effect looks substantial, although it should be borne in mind that the average extent of capital constraints faced by entrepreneurs in our sample is only 19 per cent. Thus a 1 standard deviation increase in (average) capital constraints would generate a lower average business income of 1.17 ($= 0.039 \times 30.1$) per cent. We emphasise that the estimated effect of capital constraints on performance is obtained after controlling for personal equity and capital required, the inclusion of which had little overall effect.

Next, we measure the indirect effect of schooling on performance via the capital constraint. Using (10) and (11), this can be estimated as $\hat{\beta}_{J+1}\hat{\gamma}_J = 0.039 \times 1.183 = 0.046$. This suggests a total rate of return from schooling for entrepreneurs of 18.3 per cent. A different estimate of the indirect effect can be obtained by re-estimating (11) but excluding the capital constraint variable. This will give a lower estimate because omitting capital constraints causes downward bias in the *combined* return to education. The total return to schooling is then estimated as 16.7 per cent (t-statistic=2.48, p=0.013). The implied indirect effect according to this estimate is therefore 3 per cent. Nevertheless, the range of 3.0–4.6 per cent further adds to the importance of human capital for entrepreneurial success.

C Effects from control variables

We also find some interesting effects from some of the other control variables in Table 4. Work effort measured in terms of hours worked by the entrepreneur and having a spouse work input in the business, and human capital as measured by age and general experience, are two important sets of variables that significantly and substantially enhance entrepreneurs' performance. By representing basic determinants of entrepreneurs' marginal productivity, their significance might not appear too surprising. But the *nature* of productive experience in particular is noteworthy. Several previous authors have made a distinction between experience gained in business compared with experience gained in paid employment (see, e.g., Evans and Leighton, 1989a). Here, we find that the rate of return to an extra year of *general* experience is statistically significant, being 5.8 per cent on average. This includes previous experience in business, in the same industry, and experience gained elsewhere. But no additional significant effects were found from business and same industry experience when they are entered separately. And, consistent with a large body of empirical work, the relationship between performance and age is positive and concave (see also Brock and Evans, 1986; Evans and Leighton, 1989b; and Holtz-Eakin *et al*, 1994).

The remaining control variables also have the expected effects on performance. Entrepreneurs' log incomes are higher on average for older and larger (in employment terms) businesses. These findings are consistent with Jovanovic's (1982) theory of industry evolution, reflecting survival by both the most able and also the most knowledgeable about their innate abilities in entrepreneurship. Finally, female entrepreneurs earn lower log incomes on average than their male counterparts. But this effect, which is attenuated for females with richer spouses, is on the margins of statistical significance.

D Sensitivity analysis

Below we conducted several robustness checks, to see whether our results are sensitive to different specifications or are consistent with alternative explanations.

One alternative explanation for the substantial effect of education on performance is that more educated entrepreneurs choose to operate risky projects with high rates of return. As Cocco *et al* (2004) and Gomes and Michaelides (2005) have pointed out, human capital is less risky than equities and so can substitute for bond holdings, enabling riskier non-human capital investments to be made. Hence higher levels of education might increase average performance by making the value of the human capital hedge greater (Polkovnichenko, 2003). To check for this, we split the sample into different groups by year of education and computed for each group the coefficient of variation in incomes as a measure of education-specific income uncertainty. If education is acting as a hedge in this way, we would expect to find the coefficient of variation to be related positively to years of schooling. In fact, we found a *negative* correlation between the coefficient of variation and schooling, of -0.0506, though this was insignificant (the p-value was 0.9053). Hence we conclude that our results seem to be robust to hedging properties of human capital.[20]

It is also possible that rates of return to education depend on milestones such as completing high school or college. To test this, we included and interacted dummies for completion of high school and college education with years of education in the performance equation. However, none of these additional terms were statistically significant. For example, a dummy variable indicating college dropout and its interaction with years of education achieved p-values of only 0.386 and 0.209 respectively in the performance equation. This suggests that our estimated rates of return are correctly capturing the effects of education on performance.

Another possibility is that individuals at different wealth levels face qualitatively different constraints. This possibility is suggested by the findings of Hurst and Lusardi (2004), who reported that assets only affect participation in entrepreneurship for those at the top end of the wealth distribution. To test this possibility, we defined a dummy variable, 'top', as equal to one if the respondent appeared in the top quintile of the asset distribution. Personal equity was used as a proxy for net wealth, as the latter was unavailable in our data set. This dummy was interacted with every variable in the capital constraint equation. The intercept dummy was -6.263 (t-statistic=1.65, p=0.099), while none of the other coefficients were statistically significant. This suggests that while wealth decreases capital constraints, it does not alter the relationship between capital constraints and its other determinants. However, it should be borne in mind that we are (a) using only a proxy for wealth, and (b) are analysing a sample of individuals who are all already participating in entrepreneurship.

We also explored several other possible identifying instruments for capital constraints. One of the referees asked whether variations in regional bank densities in the Netherlands might comprise a useful instrument. The idea is that entrepreneurs in high bank density areas would find it easier to undergo repeated screening by rival banks if they were given unfavourable initial loan offers. The data on number of banks per zip code area were collected from www.bedrijven.nl and entered into the capital constraints equation as an additional instrument. However, this instrument lacked power, having a partial F of only 0.004. We also tried several other candidates, including whether the business was taken over (from within or outside the family) as opposed to having been started from scratch. Capital requirements might be easier to screen if the firm already has some trading history, especially for older firms. But none of these alternative candidates for identifying instruments in the capital constraints equation possessed sufficient power either.

[20] Van der Sluis *et al* (2004) use a more elegant method based on panel data to arrive at a similar result. They calculate conditional correlations between individual income risk (measured longitudinally) and education. Of course, alternative ways of measuring risk in entrepreneurship are also possible, including one based on industry betas. However, we did not attempt to compute betas because they relate to publicly listed firms, whereas our sample contains mainly non-listed firms, including ones in sectors (such as small-scale professional and personal services) that have no direct equivalent on the stock exchange.

6 Conclusion

We investigated the extent to which the performance of a business venture, once started, is affected by capital constraints at the time of inception and by the business founder's investment in human capital. We attempted to answer this question by measuring the distinct contribution of each of these factors, taking into account the possibility that human capital might also have an indirect effect on performance by making financial capital easier to access, so diluting any capital constraint. To this end, and in recognition of the likely endogeneity of education and capital constraints, we estimated a 'triangular' model of capital constraints, years of schooling, and performance by instrumental variables (IV), using a sample of data from a rich survey of entrepreneurs conducted in the Netherlands in 1995.

Our principal findings are threefold. First, lower capital constraints lead to greater entrepreneurial performance with a 1 percentage point relaxation of capital constraints increasing entrepreneurs' gross business incomes by 3.9 per cent on average. This estimate is both statistically significant and fairly sizeable in economic terms. Second, more years of education is associated with significantly lower capital constraints. Each year of schooling decreases capital constraints by 1.18 percentage points. Third, extra years of schooling enhance entrepreneurial performance both directly and indirectly via the effect of capital constraints. The direct rate of return to schooling is estimated to be 13.7 per cent, whereas the total effect, including the indirect effect via the impact of education on capital constraints, is estimated at between 16.7 and 18.3 per cent. Our data set is limited to entrepreneurs so we cannot compare rates of return for employees and entrepreneurs directly; and there are possible limitations with the quality of the instruments available in the data that lead us to sounds a note of caution. Nevertheless, our estimated rates of return to schooling are broadly comparable with (if a little higher than) previous IV estimates obtained for employees. This is contrary to some casual 'conventional wisdom' that entrepreneurs do not need schooling to be successful.

In terms of policy implications, we believe that our results offer backing for the dual track approach to promoting entrepreneurship adopted by many governments. The dual track approach involves attempting to soften capital constraints while developing initiatives to deepen human capital. Our findings suggest that duality is especially important when human capital and financial capital are interrelated and endogenous. Thus, the power of extra education to improve entrepreneurs' performance seems to be greater when capital constraints exist, because education helps to relax these constraints as well as having a direct effect on performance. But the inter-relatedness of these phenomena prevents us from pronouncing here on the correct balance between government programs that promote human as opposed to financial capital.

Compared with the vast literature on rates of return to schooling for wage and salary workers, the literature on entrepreneurs' rates of return is much less developed. To our knowledge, this paper has made the first serious effort to measure rates of return to schooling for entrepreneurs while taking account of possible endogeneity of the schooling decision. More studies of this kind, preferably using data sets containing information on both types of worker that can also take account of selectivity bias, are needed to reach firm conclusions about the absolute and relative sizes of the returns to schooling (see, e.g., Van der Sluis *et al*, 2004). Furthermore, more detailed analysis of the kinds of schooling undertaken (e.g., subjects studied, and types of school attended) would help make policy recommendations more precise. So would the availability of data sets containing even more sophisticated instruments and more extensive control variables.

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Appendix A

Proof of Proposition 1

Proof. Consider an entrepreneur endowed with x. Given some realisation of p, an entrepreneur who is correctly identified by the screen is offered the contract $[k^e(x), r^e(x)]$, and makes *ex post* profits in non-default states of

$$\pi[k^e(x), r^e(x)] := p.f[k^e(x), x] - r^e(x)k^e(x)\,,$$

where $k^e(x) < k^*(x)$, so that the entrepreneur faces the constraint $\delta(x) = 1 - [k^e(x)/k^*(x)]$. For given $r^e(x)$, we therefore have

$$\left.\frac{\partial\pi[k^e(x), r^e(x)]}{\partial k}\right|_{k=k^e(x)} = p.f_k[k^e(x), x] - r^e(x) > 0\,. \tag{13}$$

Likewise, for given $k^e(x)$, we have

$$-\left.\frac{\partial\pi[k^e(x), r^e(x)]}{\partial r}\right|_{r=r^e(x)} = k^e(x) > 0\,. \tag{14}$$

Hence if an entrepreneur with x is mistakenly believed to have ability $x+\varsigma$, where $\varsigma > 0$, they will be offered a contract $[k^e(x+\varsigma), r^e(x+\varsigma)]$ that decreases their borrowing constraint, which becomes

$$\delta'(x) = 1 - [k^e(x+\varsigma)/k^*(x)] < \delta(x) = 1 - [k^e(x)/k^*(x)]\,.$$

This leads to higher profits by (13) and (14) above. Similarly, if the entrepreneur is mistakenly believed to have ability $x-\varsigma$, where $\varsigma > 0$, they will be offered a contract $[k^e(x-\varsigma), r^e(x-\varsigma)]$ that increases their borrowing constraint to $\delta'(x) = 1 - [k^e(x-\varsigma)/k^*(x)] > \delta(x)$ and so leads to lower profits. Therefore in both cases, and for all x, screening errors ensure that tighter borrowing constraints have a negative impact on profits, while slacker constraints have a positive impact on profits. □

Proof of Proposition 2

Proof. First note by implicit differentiation of (7) that

$$\frac{\partial k^e(x_J)}{\partial x_J} = -\frac{\int_p p f_{kx_J}[k^e(x_J), x_J]\,dG(p)}{\int_p p f_{kk}[k^e(x_J), x_J]\,dG(p)} \geq 0\,. \tag{15}$$

This derivative is strictly positive if f is non-separable in k and x_J, and is zero if it is separable.

Second, differentiate (6) to obtain

$$\begin{aligned}\frac{\partial k^*(x_J)}{\partial x_J} &= -\frac{1}{\nabla}.\left\{\int_{p\geq p^*(x_J)} p f_{kx_J}[k^*(x_J),x_J]\,dG(p)\right.\\ &\left. - \frac{\partial p^*(x_J)}{\partial x_J}[p^*(x_J)f_k[k^*(x_J),x_J]-r]\right\}, \end{aligned} \quad (16)$$

where

$$\begin{aligned}\frac{\partial p^*(x_J)}{\partial x_J} &= -\frac{rk^*(x_J).f_{x_J}[k^*(x_J),x_J]}{\{f[k^*(x_J),x_J]\}^2} < 0 \qquad \text{and}\\ \nabla &= \int_{p\geq p^*(x_J)} p f_{kk}[k^e(x_J),x_J]\,dG(p) < 0\,.\end{aligned}$$

If f is non-separable, the integral in (16) is positive. The sign of the second term depends on the sign of $[p^*(x_J)f_k[k^*(x_J),x_J]-r]$. To sign this, notice that the integrand of (6) is increasing in p and so is positive at high p. Therefore it must be negative at $p=p^*$ in order for its integral to be zero as is required by (6). Hence the first term in the braces on the RHS of (16) is positive and the second is negative, ensuring that the relationship between ability and the demand for capital (and thereby also borrowing constraints) cannot be signed unambiguously if f is non-separable. However, under separability, $f_{kx_J}[k^*(x_J),x_J]=0$, so the first term on the RHS of (16) becomes zero, ensuring that $\partial k^*(x_J)/\partial x_J<0$. Combined with $\partial k^e(x_J)/\partial x_J=0$ for this case as established above, it then follows from (5) that borrowing constraints are decreasing in observed ability. □

Proof of Proposition 3

Proof. Ex post profits in non-default states are

$$\pi[k^e(x_J),r^e(x_J)] := p.f[k^e(x_J),x_J] - r^e(x_J)k^e(x_J)\,.$$

Therefore

$$\begin{aligned}\frac{\partial \pi[k^e(x_J),r^e(x_J)]}{\partial x_J} &= \left[p.f_{k^e(x_J)} - r^e(x_J)\right].\frac{\partial k^e(x_J)}{\partial x_J}\\ &+p.f_{x_J} - k^e(x_J).\frac{\partial r^e(x_J)}{\partial x_J}\,.\end{aligned} \quad (17)$$

Now Bernhardt established that $k^e(x_J) < k^*(x_J)$, so the term in square brackets is strictly positive. Also positive is f_{x_J}; and $\partial k^e(x_J)/\partial x_J \geq 0$ from the proof of Proposition 2. Further, the proof of Proposition 2 established that $\partial p^*(x_J)/\partial x_J < 0$ so with fewer bankruptcies it follows that $\partial r^e(x_J)/\partial x_J < 0$.[21] Therefore every term in (17) is either positive or zero, establishing the proposition. □

[21] These results reflect the fact that entrepreneurs with greater human capital are less likely to default and so have less incentive to over-invest, their interests being more closely aligned with those of lenders. Recognising this, competitive lenders reward them with greater capital and lower interest rates.

Appendix B: Data

The dataset is based on an extensive questionnaire that included numerous variables containing a wide variety of information about the entrepreneurs, their backgrounds and their families. The following table shows all categories of variables, only some of which were used in our empirical analyses. The first column of the table states the categories; the second column lists the specific variables within the category; the third indicates if the specific category is used in the analyses; and the final column explains why some of the variables were not used in the analyses.

Category	Variables	Used	Not Used
Birth information	Date and gender	Birth year, gender	Birth month was tried as an instrument for education but turned out to lack power
Family background	Presence of parents, number of (older) siblings, religion	Siblings	Others were insignificant
Parental occupation and education	Occupation (self-employed, manager etc) and education level of parents	Education level of the father	Education level of the mother had too many missing values, while occupation dummies were insignificant
Statements about personal traits	Many, including shyness, assertiveness, creativeness, risk attitude etc	None used	Statements were scored retrospectively and may therefore be biased and endogenous
Education	Level, dropout, field, GPA, extracurricular activities, field courses/training	Education level	The other variables were insignificant or potentially endogenous.
Work experience	Years, unemployed periods, number of previous organizations worked for, self-employment experience, within-industry experience	All used	
Current labour market situation	Duration; work satisfaction; industry; occupation; self-assessed success; number of hours worked; income from firm in 1994; and whether partner's input is included in returns	Most used	Work satisfaction and self-rated success in 1994 are potentially endogenous, as are occupation dummies
Firm characteristics	Legal form, organizational form (including whether a franchise or independent); number of employees in each year of operation; financial leverage in each year of operation; return on sales in each year of operation; familiarity with business environment; subjective assessment of (sources of) competition in relevant environment in first and fifth year	Number of employees in current year	The other variables were either insignificant or are potentially endogenous
Labour market	Status (Employee/unemployed etc);	Status	The other variable is potentially

situation just before startup	whether managerial tasks were performed		endogenous
Start-up situation	Take-over (if so: family/non-family, age of firm); number of co-starters; number of hours worked	None used	All variables were insignificant
Behavioural characteristics prior to start-up	Longevity of the business idea; adaptation of savings behavior; start-up motivation; stated ambitions/goals; self-assessed usefulness of business plan	None used	These variables are subjective and potentially endogenous
(Start-up) capital	Amount required at start-up; actual amount used at start-up; amount of personal equity invested in the business at start-up; additional amounts required during the 1st and 2nd year after start-up; additional amount required during 3rd to 5th year; alternative sources of start-up capital requested (bank, family, venture capital etc) and which ones were successfully tapped.	Start-up capital variables	Variables relating to later years were inconsistent with others used in the empirical analysis
Other financial characteristics at start-up	Other sources of income (wage, equity, social security)	All used	
Non-financial support at start-up	Including from other entrepreneurs, science parks, banks, accountants, consultants etc; usefulness	None used	These variables are subjective and potentially endogenous
Information about partner	Presence of a partner; their education level; and the nature of their job at start-up (yes/no, tenured position, income sufficient for both)	All used	
Start up region	Zip code, familiarity with region	None used	Zip code was used to determine regional bank densities as a possible explanatory variable of capital constraints. Bank density turned out to be insignificant. Familiarity with region is subjective and potentially endogenous
Current situation	Subjective assessment of own happiness	None used	Income was judged to be a superior and objective “performance measure”
Valuation of statements	Desirability of entrepreneurship education (general, at what specific levels of education, relevant topics), how to improve legislation towards entrepreneurs	None used	Not relevant

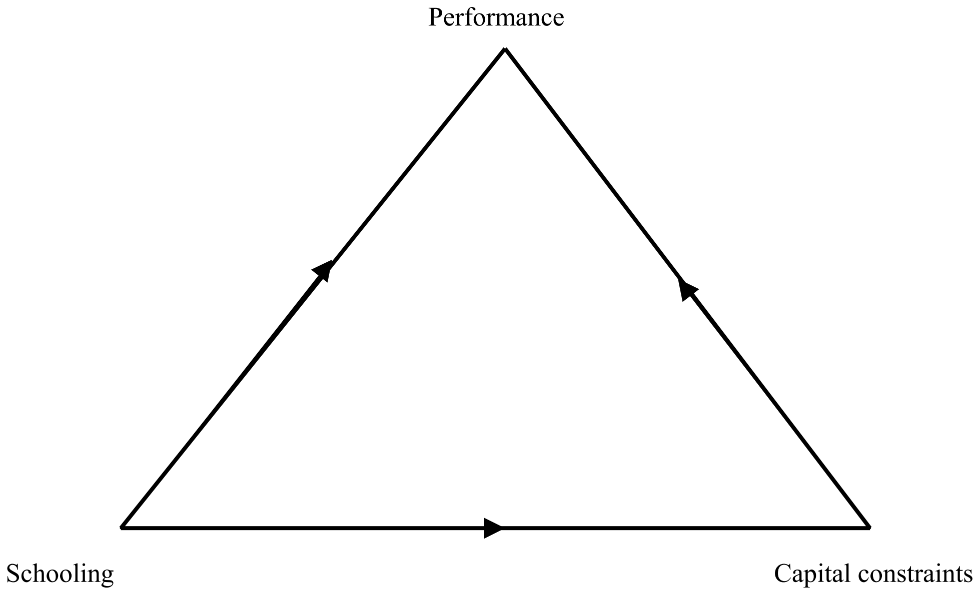

Figure 1
The Endogenous Triangle