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| Version | unknown |

SOURCE (OR PART OF THE FOLLOWING SOURCE):

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|---|---|
| Type | report |
| Title | Schooling, Capital Constraints and Entrepreneurial Performance |
| Author(s) | C.M. van Praag, S.C. Parker |
| Faculty | UvA: Universiteitsbibliotheek |
| Year | 2004 |

FULL BIBLIOGRAPHIC DETAILS:
http://hdl.handle.net/11245/1.428435

# 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 2 per cent on average. Also, education enhances entrepreneurs' performance both directly – with a rate of return of 12.7 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 0.8 and 2.4 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 constraint? 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 capital, rather than of capital constraints *per se*; and has moreover tended to treat it 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. To this end, it is necessary to recognise the potential endogeneity of error terms in performance and capital

[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).

constraint equations, which can be caused by 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 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. 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 limited liability debt contracts, 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.

Under limited liability, entrepreneurs maximise expected profits, given by

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

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

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

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

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

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

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

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 exogenous 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 the Appendix – 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

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

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

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

[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.

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

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

**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 definitely 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

[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.

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.

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

[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).

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 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.

[6]This was highlighted by Van der Sluis et al (2003), in their survey of 94 studies on the issue of entrepreneurial 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 $\theta_2$ is its estimated coefficient(s), satisfying the same conditions (i) and (ii) of validity and quality as should hold for $z_1$ and $\theta_1$. 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 (although possible) it seems unlikely 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 $\beta_J$, $\beta_{J+1}$ and $\gamma_J$, so that the three propositions of Section 2 can be tested. In short, Propositions 1 through 3 suggest the following parameter restrictions: $\beta_{J+1} < 0$, $\gamma_J \gtreqless 0$, 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 (family) business. Our focus is therefore on entrepreneurs 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 to construct a continuous capital constraint variable, combined with personal characteristics of the entrepreneur dated back to the date of start-up and earlier.

In the fall of 1994, a questionnaire was sent to approximately 1000 entrepreneurs. This generated 461 valid observations for the present analysis, which were compiled in 1995. As documented in Brouwer *et al* (1996), the sample is broadly representative of the Dutch population of entrepreneurs, apart from containing a slightly larger number of highly educated respondents.[7] Summary statistics are given in Table 1, and the correlation matrix appears in Table A1 of the Appendix.[8] 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 total gross annual business income from the venture in 1994 Dutch guilders (1.85 guilders = one US dollar in 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.[9] An advantage of using log income as a measure of performance is that it facilitates a comparison with the literature on employee earnings functions.

The next endogenous variable to define empirically is human capital ($x_J$). The aspect of human capital that we focus on here is education. It was felt that trying to endogenise alternative 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.

[7]The high average level of education attainment reflects 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.

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

[9]Every 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 at start-up by a spouse or partner.

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

| | $N$ | Mean | St. Dev. | min. | max. |
|---|---|---|---|---|---|
| **Endogenous Variables** | | | | | |
| Annual 1994 log income ($y$) | 461 | 3.53 | 1.50 | 0.00 | 6.62 |
| Years of schooling ($x_J$) | 456 | 14.78 | 3.18 | 6.00 | 18.00 |
| Capital constraint % ($x_{J+1}$) | 461 | 18.96 | 30.07 | 0.00 | 100.00 |
| **Exogenous Variables** | | | | | |
| No. siblings ($x_1$) | 461 | 3.10 | 2.40 | 0.00 | 13.00 |
| Current age ($x_2$) | 454 | 40.40 | 10.64 | 21.00 | 62.00 |
| Father's education ($x_3$) | 443 | 11.58 | 3.67 | 6.00 | 18.00 |
| Female ($x_4$) | 461 | 0.15 | 0.36 | 0.00 | 1.00 |
| *Initial human capital* | | | | | |
| Age ($x_5$) | 451 | 33.31 | 8.42 | 14.75 | 59.17 |
| Years general exp. ($x_6$) | 449 | 10.09 | 8.69 | 0.00 | 46.00 |
| Years industry exp. ($x_7$) | 461 | 4.48 | 6.52 | 0.00 | 34.00 |
| Has prev. business exp. ($x_8$) | 461 | 0.15 | 0.35 | 0.00 | 1.00 |
| Switched from PE ($x_9$) | 461 | 0.57 | 0.50 | 0.00 | 1.00 |
| *Initial financial factors* | | | | | |
| Earned wage at start ($x_{10}$) | 461 | 0.26 | 0.44 | 0.00 | 1.00 |
| Partner had suff. income ($x_{11}$) | 461 | 0.17 | 0.38 | 0.00 | 1.00 |
| Personal equity ($x_{12}$) | 448 | 20.96 | 45.01 | 0.00 | 500.00 |
| Capital required ($x_{13}$) | 461 | 65.35 | 119.03 | 1.00 | 800.00 |
| *Additional controls (y eq.)* | | | | | |
| Current firm age in years ($x_{14}$) | 458 | 7.10 | 8.16 | 0.50 | 40.50 |
| Current no. employees ($x_{15}$) | 424 | 5.05 | 17.37 | 1.00 | 300.00 |
| Weekly hours at start-up ($x_{16}$) | 442 | 51.74 | 20.24 | 2.00 | 100.00 |
| Current spouse input ($x_{17}$) | 461 | 0.25 | 0.43 | 0.00 | 1.00 |

Notes. $N$ is the number of valid observations. Income is measured in thousands of Dutch guilders, with mean 70.45 (St. Dev.=79.32). For the detailed definition of variables, see text.

To construct a measure of capital constraints, let $A$ be the amount of an entrepreneur's assets used as personal equity in the business; let $k^e$ be the total amount of capital borrowed from (possibly multiple[10] ) lenders, as before; and let $k^*$ be the desired amount of borrowing given $A$. Also, define $K^e$ and $K^*$ as the total amounts of capital *used* and *required* (rather than borrowed), respectively. Clearly $K^e = A + k^e$ 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, $\Delta$ forms the basis of our empirical measure of capital constraints.[11] As can be seen by differentiating $\Delta$ and $\delta$ with respect to $k^e$ and $k^*$, $\Delta$ possesses the same properties as $\delta$, 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

[10]Our data on capital borrowed from lenders is not restricted to bank borrowing. Reflecting 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.

[11]In particular, values of $K^e$ were given as responses to the questionnaire question 'How much capital did you need at the start of your current business?', and those of $K^*$ as responses to the question 'What was the amount of money that you actually started with?'. 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?' The latter variable allowed cross-checking and verification of the quality of the responses for amounts borrowed and needed: $k^e$ and $k^*$, respectively.

[12]Note however that because $\partial\Delta/\partial A < 0$, it follows that $\Delta < \delta$. 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 robust 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 empirical relationship might simply reflect decreasing absolute risk aversion (Cressy, 2000), or a positive competition externality (Black *et al*, 1996).

obtained from bank file data.

## 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 age, 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. 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 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

[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.

at the time of start-up) in the capital constraint equation both in levels and squares. It does not however seem likely that the origin of one's start-up capital, given a certain level of capital constraints, would affect the venture's performance. This reasoning is borne out by later empirical results, which show that this is indeed the case.

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.[16] None of these control variables are expected to influence years of schooling or capital constraints. This is because the decision to offer finance pre-dates current firm age and size; and effort 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).

# 5 Results

This section is divided into three 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 second and third parts, we present and interpret the estimated capital constraint and performance equations, respectively.

## 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.[17]

Row 1 of Table 2 presents the Hausman tests for each of the three cases. 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.

Having established that years of schooling and capital constraints are endogenous variables, we now propose suitable instrument sets $z_1$ and $z_2$ respectively. As discussed earlier, it is

[16] Work hours in the first year of a venture should therefore 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.

[17] The validity of Hausman's test depends on the underlying choice of identifying instruments satisfying the quality and validity tests – which furnishes another reason for reporting the results of these tests.

| Variables: | Schooling | | Cap. Con. |
|---|---|---|---|
| Tests | Performance eq. | Cap. Con. eq. | Performance eq. |
| **Relevance** | $t_{366} = -1.75$ | $t_{411} = 0.87$ | $t_{381} = 2.26$ |
| | [0.08] | [0.39] | [0.03] |
| **Quality** | $F(2, 428) = 29.90$ | $F(2, 428) = 29.90$ | $F(5, 409) = 7.39$ |
| | [0.00] | [0.00] | [0.01] |
| **Validity** | $F(14, 364) = 0.00$ | $F(11, 409) = 0.00$ | $F(18, 362) = 0.21$ |
| | [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.

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

necessary that these instrument sets 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 $\theta_1$ and $\theta_2$ in (9) and (10), respectively.

In the years of schooling equation (9), we propose as *identifying instruments* the respondent's father's education and the number of siblings in the respondent's family,[18] with the other instruments being age and its square (capturing possible cohort effects), and gender (see the results in the first column of Table 3). And in the capital constraint equation (10), we propose as identifying instruments the indicator variable for whether the respondent switched from paid employment (PE) just prior to starting the business, the amount of personal equity injected into the business at start-up (and its square), and the total amount of start-up capital initially required (and its square).[19]

The reason for selecting a switch from paid employment as an identifying instrument for explaining capital constraints is that such a switch might send a better signal to lenders than does a (possibly involuntary) switch from another job in self-employment or from non-participation. At the same time, a switch from paid employment should not affect *current* performance in entrepreneurship. The latter in particular is likely to depend more on experience in entrepreneurship and past experience generally. We explained in Section 4.2 why

[18]These are common though not undisputed choices – see, e.g., Blackburn and Neumark (1993, 1995). We realise that this set of instruments is disputed in the returns to schooling literature. However, the same discussions reveal that finding suitable sets of instruments is difficult and is a topic that is still developing; and we are starting the process for the entrepreneurship literature. Our choice of instruments does find empirical support in this application in terms of its validity and quality.

[19]Note that the inclusion of the left hand side variable's denominator as an exogenous variable at the right hand side of the equation poses no econometric problems of itself, and is justified for economic reasons as we go on to argue.

current performance is also unlikely to be affected by initial personal equity or the size of the initial capital requirement. This justifies their assignment as identifying instruments, though we also test the validity of the identifying restrictions explicitly below.

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 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) 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 valid. The result for the years of schooling 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 extent of entrepreneurs' capital constraints

The final column of Table 3 presents estimates of the capital constraint equation (10).[20]

The first 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 3 per cent. This result, which implies that an extra year of schooling relaxes the capital constraint by 1.175 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.

It is also of interest to interpret the other coefficients of Table 3. Strikingly, females appear to suffer less from capital constraints (ceteris paribus) than males do, holding the amount of required start-up capital constant. 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.[21] The effect of the total amount of capital

[20]Explanatory variables include years of schooling, the identifying instruments described above, and all but seven of the exogenous variables listed in Table 1. These exceptions are the two identifying instruments used for the human capital equation (i.e., 'Number of siblings' and 'Father's education'); current age (since 'age at start-up' is included to explain capital at start-up); and the four controls relating to post-start-up performance.

[21]The effect becomes positive when entrepreneurs put more than 331 thousand guilders in their business but this is the case for only 3 per cent of the sample. One possible explanation for positive effects is that unrealistic optimists tend to provide the most self-finance (De Meza and Southey, 1996).

| Variable | Schooling eqn. (9) Coeff. | t-ratio | Capital con. eqn. (10) Coeff. | t-ratio |
|---|---|---|---|---|
| Years of schooling | | | $-1.175^{**}$ | 2.13 |
| No. siblings | $-0.178^{***}$ | 2.69 | | |
| Current age | $0.287^{**}$ | 2.46 | | |
| Current age squared | $-0.004^{***}$ | 3.13 | | |
| Father's education | $0.273^{***}$ | 7.42 | | |
| Female | $-0.747^{**}$ | 2.19 | $-7.875^{**}$ | 1.96 |
| Age at start-up | | | 0.575 | 0.44 |
| Age at start-up squared | | | $-0.012$ | 0.68 |
| Years general exp. | | | 0.303 | 0.95 |
| Years ind. exp. | | | $-0.358$ | 1.45 |
| Has prev. bus. exp. | | | 4.392 | 1.03 |
| Switched from PE | | | $-8.722^{***}$ | 2.78 |
| Earned wage at start-up | | | 1.155 | 0.35 |
| Partner had suff. inc. | | | 2.804 | 0.69 |
| Personal equity | | | $-0.348^{***}$ | 4.94 |
| Pers. equity squared | | | $0.001^{***}$ | 3.98 |
| Capital required | | | $0.136^{***}$ | 3.19 |
| Cap. required squared | | | $-0.0001^{***}$ | 2.80 |
| Intercept | $8.354^{***}$ | 2.31 | 35.326 | 1.48 |
| $R^2$ | 0.31 | | 0.12 | |
| $F(k, n-k)$ | $41.69^{***}$ | | $4.01^{***}$ | |
| No. Observations, $n$ | 434 | | 425 | |

Dependent variables are defined in the text. Regressions reported with robust standard errors. $^{*}$ $p$-value less than 0.10; $^{**}p$-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.

Table 3: Estimates of the schooling and capital constraint equations

required by an entrepreneur on the extent of capital constraints is significantly positive (for 97 per cent of the sample) whereas the marginal effect decreases at increasing values of total capital required. This might reflect lenders' unwillingness to over-extend themselves on risky investment projects.

Every other variable in Table 3 is statistically insignificant, including other 'initial' human capital and financial variables. The $R^2$ of 12 per cent indicates that we have had only limited success in explaining the extent of capital constraints.[22]

## 5.3 Explaining entrepreneurs' performance

Having identified a suitable instrument set, 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.

### 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 6.9 per cent in terms of entrepreneurs' gross incomes. 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 12.7 per cent compared with 6.9 per cent.[23] The IV es-

[22]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.

[23]See, e.g., Ashenfelter *et al* (1999), whose average IV estimates of 9.3 per cent were 2.7 per cent higher

| Variable | Performance eqn. OLS | | Performance eqn. IV | |
|---|---|---|---|---|
| | Coeff. | t-ratio | Coeff. | t-ratio |
| Years of schooling | $0.069^{**}$ | 2.45 | $0.127^{*}$ | 1.93 |
| Capital constraint | $-0.004^{*}$ | 1.85 | $-0.021^{**}$ | 2.29 |
| Current age | $0.241^{***}$ | 3.91 | $0.198^{***}$ | 2.96 |
| Current age squared | $-0.004^{***}$ | 2.50 | $-0.003^{***}$ | 3.39 |
| Female | $-0.260$ | 1.24 | $-0.365$ | 1.63 |
| Years general exp. | $0.062^{***}$ | 3.25 | $0.055^{***}$ | 2.88 |
| Years ind. exp. | 0.013 | 0.95 | 0.015 | 1.03 |
| Has prev. bus. exp. | 0.172 | 0.99 | 0.293 | 1.52 |
| Earned wage at start | $-0.200$ | 1.32 | $-0.211$ | 1.36 |
| Partner had suff. inc. | $-0.018$ | 0.09 | $-0.020$ | 0.10 |
| Firm age | $0.095^{***}$ | 4.73 | $0.087^{***}$ | 4.33 |
| No. employees | $0.012^{***}$ | 3.11 | $0.013^{***}$ | 3.22 |
| Weekly hours at start | $0.015^{***}$ | 4.16 | $0.014^{***}$ | 3.85 |
| Spouse input | $0.441^{***}$ | 2.59 | $0.371^{**}$ | 2.20 |
| Intercept | $-3.083^{**}$ | 2.47 | $-2.925^{**}$ | 2.06 |
| $R^2$ | 0.25 | | 0.26 | |
| $F(14, n-14)$ | $9.81^{***}$ | | $9.62^{***}$ | |
| No. Observations, $n$ | 390 | | 371 | |

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.

Table 4: Estimates of the enterprise performance equation

timate of the rate of return to schooling is slightly less precisely estimated, being statistically significant with a p-value of 5.5 per cent only, but still supports Proposition 3. Its magnitude is a little 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. Second, they bear 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 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 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 significant only with a Type I error of 10 per cent. However, the IV estimate given in the second column is five times larger and highly significant. It implies that a 1 percentage point relaxation of capital constraints increases entrepreneurs' average business incomes by (a statistically significant) 2.1 per cent. This finding strongly supports Proposition 1.[24]

than their OLS estimates of 6.6 per cent. 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.

[24]While the size of this effect looks substantial, 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 10 per cent increase in (average) capital constraints would generate a lower average business income of 4.0 ($= 0.021 \times 0.19) \times 100$ per cent only.

Next, we measure the indirect effect of schooling on performance via the capital constraint. Using (10) and (11), this can be estimated as $\hat{\beta}_{J+1}\hat{\gamma}_J = 2\% \times 1.175 = 2.4\%$. This suggests a total rate of return from schooling for entrepreneurs of 15 per cent. A different estimate of the indirect effect can be obtained by re-estimating (11) but excluding the capital constraint variable.[25] The total return to schooling is then estimated as 13.5 per cent (t-statistic=2.13, p=0.034). The implied indirect effect according to this estimate is therefore 'only' 0.8 per cent. Nevertheless, the range of 0.8–2.4 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 previous business or same-industry experience have positive but insignificant effects on entrepreneurs' performance. In contrast, the rate of return to an extra year of *general* experience is statistically significant, being 5.5 per cent on average. And, consistent with a large body of empirical work, the relationship between performance and age is positive and concave. The peak of 34 implied by our estimates is not dissimilar to estimates reported in other work (see, e.g., 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 is not significant.

## 6 Conclusion

This paper has 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

[25]This will give a lower estimate because omitting capital constraints causes downward bias in the *combined* return to education.

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 and 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 2 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 1.175 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 12.7 per cent, whereas the total effect, including the indirect effect via the impact of education on capital constraints, is estimated at between 13.5 and 15 per cent. Our data set is limited to entrepreneurs so we cannot compare rates of return for employees and entrepreneurs directly; but 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. 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 control variables.

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# Appendix

## 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

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

where

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

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

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

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 $\partial r^e(x_J)/\partial x_J < 0$.[26] Therefore every term in (17) is either positive or zero, establishing the proposition. □

[26] 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.

Table A1. Sample correlation matrix

| | $y$ | $x_J$ | $x_{J+1}$ | $x_1$ | $x_2$ | $x_3$ | $x_4$ | $x_5$ | $x_6$ |
|---|---|---|---|---|---|---|---|---|---|
| $x_J$ | -0.10 | | | | | | | | |
| $x_{J+1}$ | -0.06 | -0.08 | | | | | | | |
| $x_1$ | 0.14 | -0.31 | -0.03 | | | | | | |
| $x_2$ | 0.27 | -0.37 | 0.02 | 0.45 | | | | | |
| $x_3$ | -0.10 | 0.39 | -0.06 | -0.24 | -0.29 | | | | |
| $x_4$ | -0.15 | -0.01 | -0.09 | -0.10 | -0.06 | 0.12 | | | |
| $x_5$ | 0.15 | -0.03 | -0.09 | 0.20 | 0.67 | -0.16 | 0.01 | | |
| $x_6$ | 0.21 | -0.24 | -0.08 | 0.17 | 0.63 | -0.21 | 0.02 | 0.81 | |
| $x_7$ | 0.20 | -0.22 | -0.07 | 0.17 | 0.40 | -0.16 | -0.05 | 0.48 | 0.57 |
| $x_8$ | 0.06 | 0.01 | 0.10 | 0.01 | 0.05 | 0.09 | -0.04 | -0.05 | 0.02 |
| $x_9$ | 0.19 | -0.14 | -0.13 | 0.14 | 0.19 | -0.14 | 0.08 | 0.17 | 0.22 |
| $x_{10}$ | -0.05 | 0.18 | 0.00 | -0.16 | -0.10 | 0.12 | 0.01 | -0.01 | -0.01 |
| $x_{11}$ | -0.09 | 0.09 | -0.01 | -0.08 | -0.10 | 0.08 | 0.27 | -0.02 | -0.05 |
| $x_{12}$ | 0.19 | -0.04 | -0.12 | 0.04 | 0.14 | -0.01 | -0.05 | 0.16 | 0.20 |
| $x_{13}$ | 0.20 | -0.16 | 0.03 | 0.19 | 0.22 | -0.07 | -0.06 | 0.15 | 0.20 |
| $x_{14}$ | 0.21 | -0.47 | 0.12 | 0.40 | 0.64 | -0.23 | -0.08 | -0.14 | 0.00 |
| $x_{15}$ | 0.36 | -0.00 | 0.07 | 0.09 | 0.14 | -0.02 | -0.05 | 0.11 | 0.08 |
| $x_{16}$ | 0.26 | -0.26 | 0.04 | 0.15 | 0.26 | -0.18 | -0.12 | 0.16 | 0.17 |
| $x_{17}$ | 0.21 | -0.31 | -0.04 | 0.24 | 0.37 | -0.22 | -0.15 | 0.13 | 0.22 |

| | $x_7$ | $x_8$ | $x_9$ | $x_{10}$ | $x_{11}$ | $x_{12}$ | $x_{13}$ | $x_{14}$ | $x_{15}$ | $x_{16}$ |
|---|---|---|---|---|---|---|---|---|---|---|
| $x_8$ | 0.03 | | | | | | | | | |
| $x_9$ | 0.19 | -0.17 | | | | | | | | |
| $x_{10}$ | -0.08 | -0.08 | 0.14 | | | | | | | |
| $x_{11}$ | -0.06 | -0.08 | 0.07 | 0.05 | | | | | | |
| $x_{12}$ | 0.05 | 0.08 | -0.01 | -0.08 | 0.05 | | | | | |
| $x_{13}$ | 0.10 | 0.06 | 0.11 | -0.02 | -0.04 | 0.52 | | | | |
| $x_{14}$ | 0.03 | 0.12 | 0.08 | -0.13 | -0.11 | 0.02 | 0.14 | | | |
| $x_{15}$ | -0.02 | 0.02 | 0.08 | -0.03 | -0.05 | 0.16 | 0.20 | 0.07 | | |
| $x_{16}$ | 0.16 | 0.12 | 0.09 | -0.29 | -0.07 | 0.16 | 0.25 | 0.18 | 0.18 | |
| $x_{17}$ | 0.16 | -0.06 | 0.08 | -0.04 | -0.16 | 0.14 | 0.14 | 0.36 | 0.08 | 0.22 |

Variable names corresponding to $y$, $x_J$, $x_{J+1}$ and $x_1, \ldots, x_{17}$ are given in Table 1.

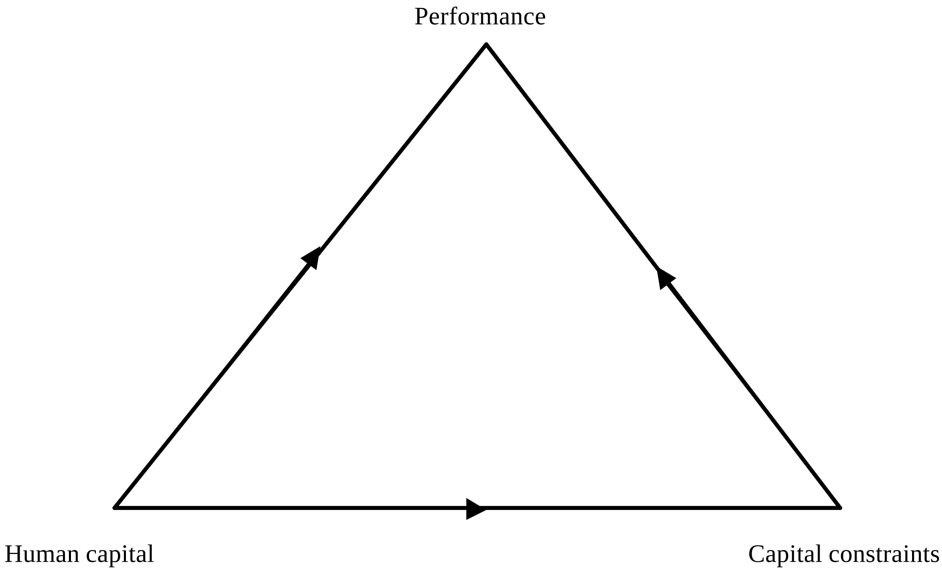


Figure 1
The Endogenous Triangle