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# Schooling, Capital Constraints and Entrepreneurial Performance: The Endogenous Triangle

Simon Parker
University of Durham

Mirjam van Praag
University of Amsterdam

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Financial Markets Group, London School of Economics and Political Science, LSE, UK
Dipartimento di Scienze Economiche e Finanziarie Prato, Università di Torino, TORINO, Italy
Centre for Financial Studies, CFS, Germany
Haute Etudes Commerciales, HEC, France
Baltic International Center for Economic Policy Studies, BICEPS, Latvia
Amsterdam University, UVA, Netherlands
Neaman Institute for Advanced Studies in Science and Technology at Technion, TECHNION, Israel
Indian School of Business, ISB, India
Tilburg University, UTIL.CER, Netherlands
University of Southern Switzerland, USI, Switzerland
The Institute of Physics, IBP, Serbia

# Schooling, Capital Constraints and Entrepreneurial Performance: The Endogenous Triangle

Simon C. Parker
Durham Business School
Mill Hill Lane
Durham DH1 3LB
United Kingdom

C. Mirjam van Praag
University of Amsterdam
Roetterstraat 11
1018WB Amsterdam
The Netherlands

**ABSTRACT**

We estimate the impact of schooling and capital constraints at the time of start-up on the performance of Dutch entrepreneurial ventures, taking into account the potential endogeneity and interdependence of these variables. Instrumental variable estimates indicate that a 1 percentage point relaxation of capital constraints increases entrepreneurs' gross business incomes by 3.9% on average. Education enhances entrepreneurs' performance both directly – with a rate of return of 13.7% — 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 3.0–4.6%.

*Keywords*: Entrepreneurship, human capital, financial constraints

## Non-Technical Summary

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? To answer this question, 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 entrepreneurs' performance.
3. Greater human capital has a negative effect on capital constraints

Method

To measure these causal effects appropriately, we model entrepreneurs' capital constraints and educational attainments as *endogenous* variables and utilize an instrumental variables approach. Using a novel sample from a rich survey of entrepreneurs conducted in the Netherlands in 1995.

Results and Implications

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. Our second contribution is to treat education as an endogenous (investment) decision that affects future earnings. 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.

Our study reveals that the returns to schooling are high for this sample of small business founders: Each year of education increases an entrepreneur's earnings by a direct 13% whereas the indirect effect of education on earnings, via the capital constraint is another 4%. 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. This finding offers 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.

## 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 (see, e.g., Evans and Jovanovic, 1989; Bates, 1990; Cooper, Gimeno-Gascon and Woo, 1994; Holtz-Eakin, Joulfaian and Rosen, 1994; Johansson, 2000; Dunn and Holtz-Eakin, 2000; and Taylor, 2001). 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 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, Harmon and Oosterbeck, 1999), the literature on the returns to entrepreneurs' human capital has yet to do so (Van der Sluis, van Praag and Vijverberg, 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 $pf(k)$, 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

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

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 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.

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. 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.

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 $EDU$, and again generalise the Bernhardt production function to become $f(k, EDU)$, with $f_k > 0$ and $f_{EDU} > 0$ as above. Also, it seems reasonable to assume that capital and human capital are complements, so $f_{kEDU}$ 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 $EDU$ changes from (2) to become

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

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

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

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

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

**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.

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.

Finally, we can derive our final proposition:

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

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 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 (e.g., Keeton, 1979; Clemenz, 1986; de Meza and Webb, 1992; and Canning, Jefferson and Spencer, 2003), rationing in the Bernhardt model is efficient. 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. 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. This variable will be denoted by $EDU$. Other human capital variables such as labour market experience are included as exogenous variables. A variable measuring the financial constraints experienced by entrepreneurs when they set up their businesses will be denoted by $CON$; its precise definition and construction will be discussed in the next section.

Consider first the effect of education on the performance of entrepreneurs, $y$ (also defined in the next section). 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.

Proposition 1 predicts that financial constraints also affect performance; but this variable might be endogenous as well. 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.

Thus consider the simple linear performance model

$$y = \beta_0 + \beta_1 x_1 + \cdots + \beta_J x_J + \beta_E EDU + \beta_C CON + u \,, \tag{8}$$

where $x_1$ through $x_J$ are exogenous variables (including past experience), and $u$ is a mean-zero disturbance term. From the foregoing we posit $\text{cov}(x_j, u) = 0$ for $j = 1, 2, \ldots, J$ but allow that $EDU$ and $CON$ might be correlated with $u$. In other words, the explanatory variables $x_1, \ldots, x_J$ are exogenous, but $EDU$ and $CON$ are potentially endogenous for the reasons given 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 measurement of the returns to schooling in *wage employment*. In contrast, with the exception of an unpublished paper by Van der Sluis, van Praag and van Witteloostuijn (2004), we do not know of any IV estimates of returns to schooling for *entrepreneurs*. 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 $EDU$:

$$EDU = \eta_0 + \eta_1 x_1 + \cdots + \eta_J x_J + \theta_1 z_1 + v\,, \tag{9}$$

where $E(v) = 0$ and where $v$ is uncorrelated with the $x_j$ $(j = 1, \ldots, J)$ and $z_1$. Condition (i) above relates to the *validity* of the (identifying) instrument(s); condition (ii) relates to the *quality* of the instruments. In a similar way we have a second reduced form equation:

$$CON = \gamma_0 + \gamma_1 x_1 + \cdots + \gamma_J x_J + \gamma_E EDU + \theta_2 z_2 + \omega\,, \tag{10}$$

where $E(\omega) = 0$, $z_2$ is the identifying instrument(s) for financial 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 $\theta_1$. Eq. (10) also generates an estimate of the effect of schooling, $EDU$, on capital constraints, where $EDU$ is taken to be exogenous in this equation. The theoretical case for endogeneity of $EDU$ 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.

The parameters of the structural performance equation (8) and the reduced forms for $EDU$ and $CON$ can be estimated by 2SLS. This renders consistent estimates of the parameters of interest, namely $\beta_E$, $\beta_C$ and $\gamma_E$, so that the three propositions of Section 2 can be tested. In short, Propositions 1 through 3 suggest the following parameter restrictions: $\beta_C < 0$, $\gamma_E \gtreqless 0$, and $\beta_E > 0$ respectively – with $\gamma_E < 0$ 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, Edelmann, van Praag and van Praag (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. We could not check whether our sample is representative in terms of average business income. But because 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.

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 on 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 profits from the venture in 1994 Dutch guilders (1.85 guilders = one US dollar in 1994). Gross business profit 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 profits rather than revenues, consistent with the discussion in Section 2; responses were obtained from one composite question in the survey questionnaire. Every respondent was assured of anonymity by the survey interviewers, though it is possible that some income under-reporting still occurred. The results will not be affected by idiosyncratic under-reporting unless under-reporting behaviour varies systematically with education and/or capital constraints; and any measurement errors that render values of $y$ 'noisy' will leave our estimates unbiased although they would increase their

standard errors. 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.

Income from businesses is measured comprehensively, including 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. (We also tried including controls for whether the business was incorporated, as incorporated firms pay their directors an 'employee' wage; but this proved to be insignificant.) An advantage of using log profit as a measure of performance is that it facilitates a comparison of the returns to education from the literature on employee earnings functions.

Unfortunately, the sample surveyors converted any negative profits 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 $\ln(1+\text{profit})$. Clearly, this treatment of negative profits 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 these results for brevity). Perhaps more important, however, is the possibility that the small number of negative incomes implies over-representation in our sample of 'successful' entrepreneurs. To the extent that is true, our results below should be treated with requisite caution.

The second endogenous variable is human capital ($EDU$). The aspect of human capital that we focus on here is education. It was felt that trying to endogenize 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*, $CON$. 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% of respondents injected at least 1000 guilders of own savings into their business at the time of start-up, and 66% 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 initial 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 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 $K^* = A + k^*$. 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?'

Now analogous to (5), the extent to which an individual is *capital constrained* can be measured as

$$\Delta := 1 - \frac{K^e}{K^*} = 1 - \frac{k^e + A}{k^* + A} \quad \in [0, 1]\,. \tag{11}$$

Because every term in (11) is measurable, $\Delta$ forms the basis of our empirical measure of capital constraints. 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 the relevant propositions of the previous section, i.e., Propositions 1 and 2, continue to apply. 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.

In our empirical work we will work with the scaled capital constraint variable $CON := 100\Delta$. Arguably, $CON$ 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. Previous empirical research suggests a positive relationship between financial *capital* and entrepreneurial entry and performance (e.g., Evans and Jovanovic, 1989; Holtz-Eakin *et al*, 1994). 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, de Meza and Jeffreys, 1996). Furthermore, recent research (Hochguertel, 2003; Hurst and Lusardi, 2004) casts doubt on the robustness of this relationship.

Another advantage of $CON$ 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 $CON$ 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.

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 Instruments and Control Variables**

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

The identifying instruments used in the schooling equation (9) are the respondent's father's education (measured as years of schooling) 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 current 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. Note that there is no necessary reason why capital intensiveness should impact on performance.

We define the following industries as capital intensive: manufacturing (including production and construction) and transportation (including storage). These industries had the highest ratio of fixed assets to wage costs (our measure of capital intensiveness) in 1994 according to Dutch Bureau of Statistics (CBS) data. Man-

ufacturing and transportation both ranked equal highest with a ratio of 3.3. Together, their share of fixed assets amounts to 64.6%, whereas their share of employees amounts to 34.9%. These industries comprise 13% of our sample (Table 1). The other 87% of the firms in our dataset are in the following industries: retail and wholesale trade (including restaurants, hotels and pubs); services (professional, financial, and 'other'); repair; agriculture; recreation; education and research; health and social care; and agriculture. The capital intensity of these other industries ranged from 1.1 (professional services) to 2.4 (agriculture).

The other variables used in the capital constraint and performance equations include (endogenous) years of schooling, gender, and several exogenous *initial human capital* variables. The latter set of variables includes 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. 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).

Performance 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. 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.

From (11), the extent of capital constraints is a decreasing function of initial personal equity, $A$, and an increasing function of total capital required, $K^*$. But both variables might have additional effects by affecting also the 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 these two variables (which are measured at the time of start-up) in the capital constraint and performance equations both in levels and squares.

Other control variables that are likely to affect entrepreneurs' current performance — but not their historical education decision and initial capital constraints — include the current age of the firm; current firm size (measured by the number of full-time equivalent employees, including the entrepreneur him or herself); and

the average weekly number of hours worked in the first year of the venture.

## 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 evaluate our choice of instruments. In the remaining parts, we present and interpret the schooling, capital constraint, and performance equations.

### 5.1 Importance of 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.

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, Jaeger and Baker (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. 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) 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. However, Sargan's test can only be performed if more than one identifying instrument is used. Therefore, the validity of the instrument 'capital intensity' proposed for the capital constraint equation can, unfortunately, not be tested. This explains the blank cell in the last row and column of Table 2. The first two columns of row 3 of Table 2 show that the instruments proposed for the schooling decision are indeed valid for equations (9) and (10) according to Sargan's F-statistic. 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 identifying instruments and controls for which the values were known at the time the schooling decision was taken (equation 9) and at the time the business was started up (equation 10). 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. We also tried alternative identifying instruments based on religious affiliation of schools and the birth month of the respondent, but neither of these variables was statistically significant. We therefore proceed using both identifying instruments.

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%. This result, which implies that an extra year of schooling relaxes the capital constraint by 1.18%, 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 other coefficients in 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 behaviour 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 personal 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% of respondents have net negative 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% indicates that we have had only limited success in explaining the extent of capital constraints, which is consistent with our earlier assumptions of unobserved ability and lender screening errors that underlies Proposition 1. No doubt this result 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. Indeed, 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, such as the legal form and structure of the start-up and familiarity with the business environment, were significant in the capital constraint equation. 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. Also, 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. (8), 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.

<u>Entrepreneurs' Returns to Schooling</u>.

The first column of Table 4 shows the (biased) estimation results that ensue when estimating (8) by OLS. It reports an average rate of return to schooling of 7.2%, 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% 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% compared with 7.2%. For example, the average IV estimates of Ashenfelter *et al* (1999) were nearly 3% higher than their OLS estimates, while Harmon and Walker (1995) and Lemieux and Card (1998) recorded even larger differences between IV and OLS. Our IV estimate, which remains statistically significant, 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%.

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, especially if the social as well as private returns to education are higher for entrepreneurs than for employees. 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 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 capital constraints, increases further the total impact of years of schooling on entrepreneurs' business incomes.

<u>The Role of Capital Constraints</u>.

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%. 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%. Hence, if the capital constraints of an entrepreneur with average capital constraints are alleviated by 10%, i.e. 1.9 percentage points, the resulting income change is $0.039 \times 1.9 = 7.4\%$. 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 (8), this can be estimated as $\hat{\beta}_C \hat{\gamma}_E = 0.039 \times 1.183 = 0.046$. This suggests a total rate of return from schooling for entrepreneurs of 18.3%. A different estimate of the indirect effect can be obtained by re-estimating (8) 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% (t-statistic=2.48, p=0.013). The implied indirect effect according to this estimate is therefore 3%. Nevertheless, the range of 3.0–4.6% further adds to the importance of human capital for entrepreneurial success.

<u>Effects from Control Variables</u>.

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% 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.

<u>Sensitivity Analysis</u>.

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, Gomes and Maenhout (2005) 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). On the face of it, this suggests that our results seem to be robust to hedging properties of human capital. However, as a referee pointed out, our data set may be susceptible to a survivorship bias which is especially pronounced for the riskier businesses; and we do not have data on the *systematic* component of entrepreneurial returns, for which time series data are needed. So we are forced to accept that our results do not conclusively rule out the possibility that more educated entrepreneurs undertake riskier projects.

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.

Next, we checked whether the results change when the sample is restricted to younger entrepreneurs (say younger than 30 or 40 at the start). As an anonymous referee pointed out, younger entrepreneurs might have less wealth and so may face greater capital constraints. In fact, restricting the sample in this way yielded results that were qualitatively the same as for the entire sample — although some of the relationships lacked

significance due to the small resulting sample size. Moreover, including a dummy variable that differentiated younger entrepreneurs from older ones in the capital constraint and performance equations did not yield any significant results. These findings bear out the results in Table 3 showing that capital constraints do not seem to vary significantly with age.

Finally, we 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 statistic 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 the alternative candidates for identifying instruments in the capital constraints equation possessed sufficient power either.

## 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' profits by 3.9% 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%, 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%. Our data set is limited to entrepreneurs so we cannot compare rates of return for employees and entrepreneurs directly; and limitations in the quality of the available instruments prompt us to sound 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 simultaneously 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

### A.1 Proof of Proposition 1

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

$$\left.\frac{\partial\pi[k^e(x), r^e(x)]}{\partial k}\right|_{k=k^e(x)} = p.f_k[k^e(x), x] - r^e(x) > 0\,. \tag{A.1}$$

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

$$-\left.\frac{\partial\pi[k^e(x), r^e(x)]}{\partial r}\right|_{r=r^e(x)} = k^e(x) > 0\,. \tag{A.2}$$

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 (A.1) and (A.2) 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.

### A.2 Proof of Proposition 2

First note by implicit differentiation of (7) that

$$\frac{\partial k^e(EDU)}{\partial EDU} = -\frac{\int_p pf_{kEDU}[k^e(EDU), EDU]\,dG(p)}{\int_p pf_{kk}[k^e(EDU), EDU]\,dG(p)} \geq 0\,.$$

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

differentiate (6) to obtain

$$\frac{\partial k^*(EDU)}{\partial EDU} = -\frac{1}{\nabla}.\Bigg\{\int_{p\geq p^*(EDU)} pf_{kEDU}[k^*(EDU), EDU]\,dG(p) - \frac{\partial p^*(EDU)}{\partial EDU}[p^*(EDU)f_k[k^*(EDU), EDU] - r]\Bigg\}\,, \tag{A.3}$$

where

$$\frac{\partial p^*(EDU)}{\partial EDU} = -\frac{rk^*(EDU).f_{EDU}[k^*(EDU), EDU]}{\{f[k^*(EDU), EDU]\}^2} < 0 \qquad \text{and}$$

$$\nabla = \int_{p\geq p^*(EDU)} pf_{kk}[k^e(EDU), EDU]\,dG(p) < 0\,.$$

If $f$ is non-separable, the integral in (A.3) is positive. The sign of the second term depends on the sign of $[p^*(EDU)f_k[k^*(EDU), EDU] - r]$. 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 (A.3) 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, $f_{kEDU}[k^*(EDU), EDU] = 0$, so the first term on the RHS of (A.3) becomes zero, ensuring that $\partial k^*(EDU)/\partial EDU < 0$. Combined with $\partial k^e(EDU)/\partial EDU = 0$ for this case as established above, it then follows from (5) that borrowing constraints are decreasing in observed ability.

### A.3 Proof of Proposition 3

*Ex post* profits in non-default states are

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

Therefore

$$\frac{\partial \pi[k^e(EDU), r^e(EDU)]}{\partial EDU} = \left[p.f_{k^e(EDU)} - r^e(EDU)\right].\frac{\partial k^e(EDU)}{\partial EDU} + p.f_{EDU} - k^e(EDU).\frac{\partial r^e(EDU)}{\partial EDU}\,. \tag{A.4}$$

Now Bernhardt established that $k^e(EDU) < k^*(EDU)$, so the term in square brackets is strictly positive. Also positive is $f_{EDU}$; and $\partial k^e(EDU)/\partial EDU \geq 0$ from the proof of Proposition 2. Further, the proof of Proposition 2 established that $\partial p^*(EDU)/\partial EDU < 0$ so with fewer bankruptcies it follows that $\partial r^e(EDU)/\partial EDU < 0$. Therefore every term in (A.4) is either positive or zero, establishing the proposition.

## APPENDIX B

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 analysis. 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 analysis; and the final column explains why some of the variables were not used in the analysis.

Table B.1 Data

| **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 endogenous |
| 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 labor 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 |

Contd.

| Category | Variables | Used | Not Used |
|---|---|---|---|
| Firm characteristics | Legal form, industry, 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, industry (to define capital intensive industries) | The other variables were either insignificant or are potentially endogenous |
| Labor market situation just before startup | Status (Employee/unemployed, etc); whether managerial tasks were performed | Status | The other variable is potentially 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 |
| Behavioral 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 amount required during the $1^{st}$ and $2^{nd}$ year after start-up; additional amount required during the $3^{rd}$ to $5^{th}$ year; alternative sources of start-up capital requested (banks, 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 |

Contd.

| Category | Variables | Used | Not Used |
|---|---|---|---|
| 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 | Irrelevant |

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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 ($EDU$) | 455 | 14.78 | 3.18 | 6.00 | 18.00 |
| Capital constraint % ($CON$) | 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.

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** | $F(20, 349) = 0.01$ | $F(16, 393) = 0.02$ | |
| | [1.00] | [1.00] | |

NOTES: 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 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 *EDU* | | | $-1.18^{**}$ | 2.20 |
| No. siblings | $-0.18^{***}$ | 2.71 | | |
| Current age | $0.29^{**}$ | 2.50 | | |
| Current age squared/10 | $-0.04^{***}$ | 3.15 | | |
| Father's education | $0.28^{***}$ | 7.42 | | |
| Female | $-0.78^{**}$ | 2.25 | −0.84 | 0.17 |
| Female × Partner suff. inc. | | | $-18.03^{**}$ | 2.15 |
| Partner suff. inc. | | | 8.78 | 1.77 |
| Age at start-up | | | 0.29 | 0.23 |
| Age at start-up squared | | | −0.01 | 0.38 |
| Years general exp. | | | 0.22 | 0.68 |
| Years ind. exp. | | | −0.39 | 1.60 |
| Has prev. bus. exp. | | | 5.44 | 1.29 |
| Switched from PE | | | $-9.36^{***}$ | 3.00 |
| Earned wage at start | | | 0.95 | 0.29 |
| Personal equity | | | $-0.34^{***}$ | 5.03 |
| Pers. equity squared/10 | | | $0.01^{***}$ | 3.88 |
| Capital required | | | $0.14^{***}$ | 3.32 |
| Cap. req. squared/100 | | | $-0.01^{***}$ | 2.96 |
| Cap. intensive industry | | | $8.72^{**}$ | 2.06 |
| Intercept | $8.22^{***}$ | 3.54 | 36.65 | 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", "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).

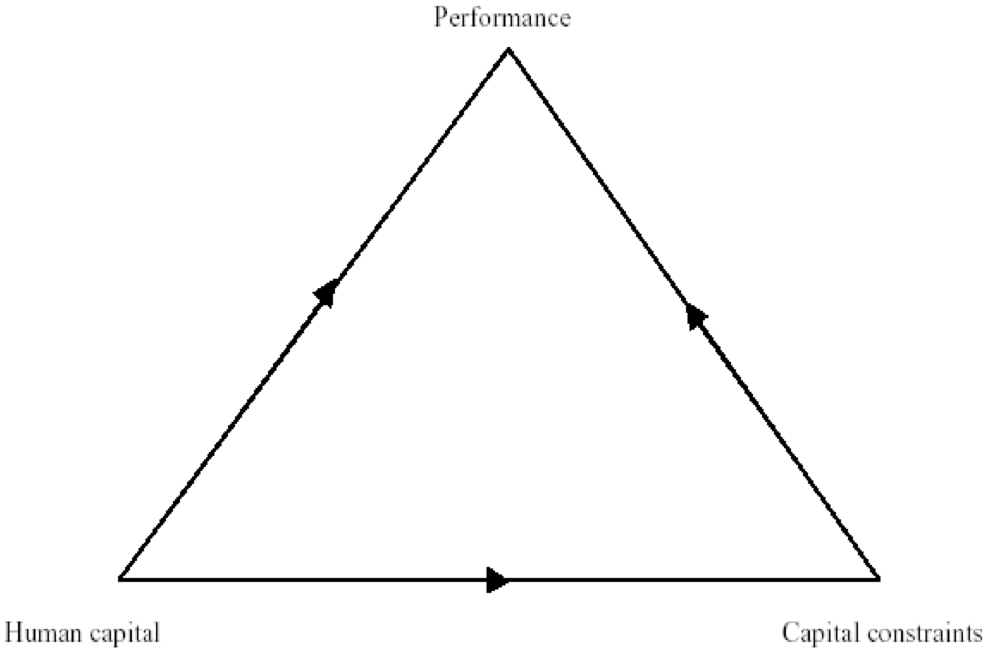
Table 4: Estimates of the Enterprise Performance Equation

| | Performance eqn. OLS | | Performance eqn. IV | |
|---|---|---|---|---|
| Variable | Coeff. | t-ratio | Coeff. | t-ratio |
| Years of schooling $EDU$ | 0.072** | 2.45 | 0.137** | 2.01 |
| Capital constraint $CON$ | −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 | 0.000 | 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 is defined in the text. 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.

Figure 1

The Endogenous Triangle


Performance
Human capital
Capital constraints