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ABSTRACT

We model investment in entrepreneurial human capital (EHC) - the representative enterprise's share of production capacity allocated to investment in innovative industrial and commercial knowledge – as a distinct channel through which firm-specific human capital drives endogenous growth. Our model suggests that institutional factors supporting free markets for goods and ideas, and higher educational attainments of entrepreneurs and workers, enhance endogenous economic growth by augmenting the efficiency of investment in EHC rather than exclusively by themselves. We test these implications using data from Global Entrepreneurship Monitor's Adult Population Survey of 63 countries over 2002-2010 and find robust support for these hypotheses.

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1. Introduction

The relation between entrepreneurship and economic growth has been the subject of a voluminous literature. The literature has its origins in the classical work of Frank Knight's (1921) risk-bearing theory of entrepreneurial action and Schumpeter's (1942) theory of innovation where entrepreneurship and competition fuel growth through creative destruction. Much of the theoretical literature on endogenous growth has focused on the role of an R&D production sector that yields vertical or horizontal product innovation and thereby productivity and per-capita income growth (e.g. Stokey, 1988; Romer, 1990; Aghion and Howitt, 1992). However, in these models the motivating force is the conventional profit maximization; entrepreneurship is by and large a hidden factor in these studies. Also, the bulk of the empirical literature on entrepreneurship and economic growth has treated entrepreneurship as an exogenous variable, and economic growth as a resulting change in either the level or the growth rate of per-capita income[1]. There is however a growing theoretical literature that treats entrepreneurship as a distinct choice variable within an endogenous growth framework, which we summarize in the literature review section of this paper (e.g., Schmitz, 1989; Iyigun and Owen, 1999; Braumerhjelm et al, 2010). A few empirical studies have attempted to treat both entrepreneurship and the growth rate of per-capita income as endogenous variables (e.g. Carree et al., 2002), but these papers have not implemented an endogenous growth framework to derive their tested hypotheses.

The distinct feature of our paper relative to the extant literature is that we treat entrepreneurship as a special form of human capital that is generated within a representative enterprise and can thus affect both the enterprise's current level of output as well as its long-term self-sustaining growth potential. The basic thesis is that innovative entrepreneurship can be thought of as a dynamic store of entrepreneurial knowledge. Modeling that knowledge as firm-specific entrepreneurial human capital (EHC) allows us to treat its accumulation as an outcome of deliberate and continuing investments in innovative commercial and industrial knowledge which takes place at the enterprise level beyond the acquisition of formal schooling. Put differently, the thesis identifies investments in innovative entrepreneurial capital, rather than simply the share of entrepreneurs in the labor force, as a distinct engine of productivity growth. This specific type of human capital, enabled by higher education and institutional factors, complements more basic channels of human capital formation, and links directly measures of entrepreneurial investments with measures of real output and per-capita income.

Our model distinguishes between two types of entrepreneurial activities: innovative and managerial. Managerial activities focus on utilizing current resources to enhance current production, sales, and profits. Innovative activities focus more on entrepreneurial intermediation between what Coase (1974) calls the "market for goods" and the "market for ideas", by discovering, absorbing, enhancing and implementing basic technological breakthroughs and turning them into product and process innovations that enhance future profits. Investment in innovative commercial knowledge are thus inherently an endogenous variable, and as such they are affected by the entrepreneur's initial general human capital and ability, but also by institutional, legal, and economic policy factors affecting the *incentives* to generate and translate new knowledge into new goods or production processes, and thereby productivity growth. The accumulated stock of entrepreneurial human capital (EHC) enhances the effectiveness of both types of entrepreneurial activities.

We model the influence of the competing roles of investment in entrepreneurial human capital by developing an endogenous-growth model of the Lucas (1988) - and Ehrlich et al. (1994) - type that formalizes the role of EHC as a distinct asset that enhances the balanced goods-production growth path in the representative entrepreneur's infinitely lived enterprise. At the same time we specify the process through which EHC can be accumulated through the entrepreneur's optimal investment in this asset, which maximizes the enterprise's utility as well. In this approach, investment in entrepreneurial capital becomes a critical factor influencing the current level vs. long-term rate of productivity and real per-capita income growth.

This framework allows us to offer closed-form balanced-growth solutions to the basic control variables of the model, and to derive a set of testable propositions concerning the determinants of both investments in innovative EHC and the latter's impact on aggregate growth dynamics. The model implies that the share of the enterprise's production capacity allocated to innovative entrepreneurship is a driving force behind the enterprise's long-run *rate* of economic growth while the complement share allocated to managerial entrepreneurship expands the *level* of the dynamic growth path over the transition to a steady state of balanced growth. The allocation of productive resources between innovative and managerial activities, in turn, is influenced by predetermined institutional factors as well as by the entrepreneurs' previously accumulated human capital level.

This analytical framework also allows us to address 3 challenges facing the human-capital-based endogenous growth literature: First, the paradigm is based on the idea that "human capital" – a store of human knowledge and productive capacity – is the central engine of economic growth, essentially because knowledge is the only economic asset that is not subject to diminishing returns (Lucas 1988; Becker, Murphy and Tamura, 1990; Ehrlich and Lui, 1991; Ehrlich and Kim, 2007). Studies that have tried to confirm this idea empirically, however, have met mixed success when using alternative schooling attainments measures as proxies for human capital. These studies do confirm that general education, or formal schooling, raises the level of per-capita GDP, but the results concerning schooling's impact on the rate of economic growth have been more mixed (see e.g., Bils and Klenow, 2000; Barro 1991; Ehrlich 2007). In this study we aim to get inside the "black box" connecting growth in knowledge with growth in productivity and real income, by identifying *entrepreneurial* human capital as a special type of applied industrial and commercial knowledge that can be propagated through entrepreneurial investments in new products and production processes and thus yield sustainable productivity and income growth. Moreover since innovative entrepreneurship is an intermediary between scientific innovations and marketable applications, general human capital, especially higher education, remains an underlying driver of growth, partly by enhancing investments in EHC.

Second, as we pointed out earlier, there has been an extensive empirical literature investigating the impact of entrepreneurship on economic growth – both level and rate. But the findings have also been mixed (Blanchflower, 2000; Audretsch & Keilbach, 2004; van Stel et al., 2005; Klapper et al., 2010; Braunerhjelm et al., 2010). In these studies entrepreneurship is treated empirically as an exogenous variable and typically proxied by the total number of entrepreneurs rather than investment in entrepreneurial human capital. This paper aims to test whether the treatment of entrepreneurship as a specific type of human capital could yield more conclusive insights about its role as a determinant of a self-sustaining balanced growth equilibrium.

Third, human capital *formation*, of any form, is least in part a product of underlying institutional factors and reinforcing economic policies as well as a legal environment, governing the return to this asset. We argue that entrepreneurial human capital, as a specific kind of human capital, should indeed be influenced by institutional factors that augment the incentive to both innovate and produce in a competitive market economy (Ehrlich, 2007), thereby also linking the markets for ideas and goods a la Coase (1974).

The testable hypotheses of the model are implemented through an econometric model treating both investment in entrepreneurial human capital and economic growth as endogenous variables. The model is specified as a two-step recursive system explaining and linking both the rate of investment in entrepreneurial human capital and its impact on per-capita income's dynamic growth path. We test these hypotheses using international panels of 17 and 63 countries over the period 2002-2010 and find strong supporting evidence for our basic propositions.

The paper proceeds as follows. Section 2 reviews the literature that is most related to our paper. Section 3 presents an endogenous growth model that fleshes out the role of entrepreneurial human capital. In section 4, we develop the econometric model we use to test our theoretical predictions, and in section 5 we present our empirical findings. Section 6 offers concluding remarks.

2. Literature Review

Previous literature has analysed the link between entrepreneurship and economic growth using neo-classical or endogenous growth settings. We here review a set of these papers that are relevant to our work, which we group under three broad categories.

a. Papers addressing the correlation between entrepreneurship and economic growth

The bulk of the empirical literature on the topic has treated entrepreneurship as an exogenous variable in analyzing its effect on the level or growth rate of output per-capita. Studies focusing on the level effects of entrepreneurship generally report a positive relationship. Audretsch and Keilbach (2004) argue that while the concept of entrepreneurial capital is unobservable, it can be proxied by the number of start-ups in a given region and report that this variable has a positive impact on GDP across 327 West German regions in the period 1989-1992. Utilizing the World Bank Group Entrepreneurship Survey), Klapper et al. (2010) find that measures like business density, entry rate and entry per capita are positively correlated with GDP per capita in 101 countries from 2000 to 2008.

The findings concerning the effect of entrepreneurship on the growth rate of output, however, are mixed. Some studies find that entrepreneurship has a positive effect on economic growth (e.g, Braunerhjelm et al., 2010); others find that entrepreneurship has a negative effect on economic growth (e.g, Blanchflower, 2000); and yet others report both positive and negative effects (e.g. Salgado-Banda, 2007.

The mixed evidence is in part due to different measurements of entrepreneurship, heterogeneity in the types of entrepreneurs being surveyed, and variations in the level of development across countries. There is little consensus about the relevant definition of entrepreneurship.[2] Some go back to Frank Knight (1921) who stresses the risk-bearing aspect of entrepreneurship, and Joseph Schumpeter (1942) who emphasizes innovation as the defining feature of entrepreneurship. Since no coherent theoretical definition of entrepreneurship has yet been widely accepted, empirical studies employ different measures, often induced by the availability of data. Measures most frequently used include the self-employment rate in the population or labor force, business ownership rate, new business start-up rate, total early-stage entrepreneurial activity, and the share of small and medium-sized enterprises or young enterprises among all enterprises.

b. Papers treating growth as endogenous and R&D as engine of growth

This literature is largely an extension of the neo-classical growth model in which technological improvements are exogenous and entrepreneurship plays no explicit role. In an attempt to endogenize technological innovations at the firm level these papers include some form of R&D production as an engine of endogenous innovation and growth in addition to goods production.

One strand of this literature introduces vertical innovation (quality ladder) models in which the improvement in product quality serves as the source of productivity growth and thus of cost reduction per quality units and therefore plays a role of the engine of real per-capita income growth (e.g. Stockey, 1988; Aghion and Howitt, 1992). In Aghion and Howit's (1992) model, innovation is formalized as a "creative destruction" process adopting the Schumpeter's original thesis. The other strand focused on horizontal innovation with new varieties of goods invented by R&D serving as the engine of growth (e.g. Romer, 1990). Papers in both of these strands suggest that an increase in resource allocation toward innovation and R&D activities results in a higher income growth rate and ascribe these activities to entrepreneurial efforts. However, these efforts are not modelled explicitly in these papers in a way that leads to testable propositions.

c. Papers treating both entrepreneurship and economic growth as endogenous

There are several studies that treat both entrepreneurship and economic growth as endogenous variables, which are more relevant to our paper.

Schmitz (1989) presents an endogenous growth model that explicitly links entrepreneurship decisions with economic growth. In this model, an individual chooses whether to become an entrepreneur or an employee; entrepreneurs imitate technologies developed by innovators in a learning-by-doing fashion; and in this process entrepreneurs augment the stock of knowledge. The model predicts that more entrepreneurs are always associated with higher economic growth because a greater percentage of existing knowledge is put to use. This prediction has not been subjected, however, to any discriminating empirical tests.

Braumerhjelm et al. (2010) modify Romer's (1990) endogenous growth model by assuming that knowledge is produced not just by R&D workers in incumbent firms, but also via entrepreneurial start-ups, which do not engage in research. The model's main argument is that knowledge stock produced by the research has little impact on growth per se, unless it is transformed into commercial use via entrepreneurship. Thus, incumbent firms in this model employ researchers to produce new inventions and varieties of products while entrepreneurs use their entrepreneurial abilities, along with the current stock of knowledge, to introduce new products and business models, such as Starbucks in the US and Ikea in Sweden. The model is based on the micro foundation of occupational choice, with the considerations of agents' entrepreneurial efficiency, ability, and proclivity to assume risky entrepreneurial returns. A basic proposition of the paper is that the balanced growth rate is independent of the distribution of labor between the R&D (research) sector and the "entrepreneurship" (start-ups) sector.

The authors put this proposition to an empirical test. Using the proportion of self-employed in the population as a proxy for entrepreneurial start-ups and trade union density as an (in)efficiency parameter, respectively, they find, contrary to the basic proposition of their model, that the distribution of labor between the research sector and the entrepreneurial sector does matter: the entrepreneurs, rather than researchers, have a significantly positive impact, while labor union density has an insignificant impact on the annual growth rate of real GDP for 17 OECD countries over the period 1981-2002. The empirical implementation in this study is limited, however, in that it treats entrepreneurship as an exogenous variable, unlike their theoretical analysis which treats this variable as endogenous. Moreover, the use of the self-employed to account for entrepreneurs, let alone innovative entrepreneurs, may be problematic, since the self-employed include shopkeepers, sole proprietors, and other unskilled individuals who choose self-employment largely due to the lack of viable salaried employment alternatives**.**

Iyigun and Owen (1999) is perhaps the closest to our model in identifying entrepreneurial human capital accumulation as a growth engine. Their model distinguishes between two types of human capital: entrepreneurial and professional. A key difference between these two is that the salaries paid to professional human capital are certain but the payoff to entrepreneurial human capital is not. Entrepreneurial human capital is augmented via learning by doing and accumulated work experience, whereas professional human capital is accumulated through formal education. These two types of human capital compete for an individual's time during their accumulation, but they complement each other in the process of production. One of the model's main testable propositions is that as an economy develops, individuals allocate more time to the accumulation of professional, relative to entrepreneurial human capital. This proposition follows from the strong assumption that skill-biased technological innovation increases more intensely the productivity of time allocated to accumulation of professional human capital. The model thus predicts that economic development is associated with a decrease in the number of entrepreneurs relative to professionals. The authors do not subject this proposition and related implications of their model to any systematic empirical tests.

There are only a few empirical studies that treat both entrepreneurship and economic growth as endogenous. Using business ownership as a proxy for entrepreneurship and specifying the equilibrium level of business ownership as a function of the log of GDP per capita, Carree et al. (2002) study 23 OECD countries over the period 1976-1996. The authors run a regression of the growth rate of GDP per capita on the absolute deviation of the business ownership rate from its equilibrium rate. The coefficient associated with this deviation is estimated to be negative and significant, suggesting that too high or too low business ownership rate can be detrimental to growth. The study finds that most countries have a business ownership rate below its corresponding equilibrium value (a notable exception being Italy). The authors thus conclude that most countries would experience a gain in growth in response to a rise in business ownership. However, the study does not provide a formal theoretical framework that sheds light on possible explanations for this finding.

In sum, a common feature of all of the papers reviewed in this section is their emphasis on labor market choices which affect the share of entrepreneurs in the population, or the distribution of workers between R&D and entrepreneurial activities, as the basic decision variable affecting productivity and per-capita income growth. Comparably less attention is given to entrepreneurial choices that drive ***innovative*** investments in reproducible entrepreneurial human capital. In the following section, we investigate this issue by modelling the entrepreneur's basic decision variable as the optimal allocation of the enterprise's production capacity between innovative activities, which contribute to the formation of future entrepreneurial human capital, and managerial activities, which contribute largely to expansion of current output. We thus focus on investment in EHC as a distinct growth engine that affects persisting formation of EHC, and thus the balanced growth path of real per-capita income in a perpetual growth equilibrium.

3. The Model

To explore the role of entrepreneurship in the process of long-term, persistent growth we develop an endogenous growth model with innovative entrepreneurial activities serving as an important channel of influence. We identify entrepreneurial human capital as a special type of applied knowledge that acts as an intermediary between the market for ideas, or basic knowledge, and the market for goods, where the basic knowledge is converted into commercial store of knowledge, or entrepreneurial human capital, by allocating a fraction of the firm's production capacity into deliberate investment in this firm-specific asset. The model adopts the basic analytical framework developed in Lucas (1988) and Ehrlich et al. (1994), and extends it to incorporate the role plaid by the representative enterprise in bringing about a balanced growth path through continuous accumulation of entrepreneurial human capital (EHC).

The economic environment and basic choice variables: We consider a closed and competitive economy without an explicit role for government and with a given population size. We take as given both fertility and parental investments in children's formal schooling in order to focus on the role of investment decisions by entrepreneurs at the representative firm level.

For simplicity, we abstract from the occupational choice problem involving the choice between being an entrepreneur or a wage worker, and assume that each agent represents an entrepreneur and a worker. Since each agent runs a productive enterprise, population size, N, also represents the number of goods-producing enterprises (firms). Agents are infinitely lived and make both production and consumption decisions, which do not include a separate demand for leisure. The economy is competitive, assuring full employment for all N agents.

Goods-production and the role of entrepreneurial human capital: We assume that each entrepreneur (agent) possesses a cumulative stock of firm-specific entrepreneurial human capital (EHC), denoted by E(t). EHC is a specific kind of commercial knowledge, embodied in the entrepreneur or the firm, which enables efficient management of current production and provides the capacity to translate basic scientific knowledge into innovative marketable products and services, as well as the capacity to involve the firm's labor inputs in the formation of such knowledge. All components of E(t), in turn, can be enhanced by *investment* in innovative entrepreneurial capital. Specifically, each entrepreneur can allocate a fraction $(1-\varepsilon)$ of the enterprise's resources and production capacity (normalized to be 1) to managing and directing current production (managerial activities), and the remaining fraction ε to investment in EHC that generates commercial innovations. The effective labor force in the economy thus becomes $N(t)E(t)[1-\varepsilon(t)]$, empowered by entrepreneurial human capital E(t). Goods are produced via a Cobb Douglas production function:

(1) $Q(t) = \mathrm{A(V)}K(t)^{\beta}\{N(t)E(t)[1-\varepsilon(t)]\}^{1-\beta}$

where 0<β<1, and K(t) denotes the accumulated stock of physical capital. A represents an exogenous technological factor which augments the productivity of all productive inputs. We assume that the level of A is affected by a vector of exogenous environmental factors, V, which can influence the external environment for doing business in a favorable or adverse way. We include as environmental factors the predetermined stock of formal schooling in the population, the degree of government intervention in private economic activity, and the economy's stage of development.

Output per enterprise, q(t) ≡ Q(t)/N(t) is therefore a function of entrepreneurial human capital E(t) and the capital/labor ratio k(t) ≡ K(t)/N(t):

(1*a*) $q(t) = \mathrm{A(V)}k(t)^{\beta}\{E(t)[1-\varepsilon(t)]\}^{1-\beta}$

The entrepreneurial human capital production function: The production function of entrepreneurial human capital at the enterprise level is given by:

(2) $\dot{E}(t) \equiv dE(t)/dt = IhE(t)\varepsilon(t)$

This production function implies that entrepreneurial knowledge accumulation is the result of a continuing rate of investment in innovative knowledge, ε(t), that takes place at the enterprise level beyond formal schooling. The investment's efficiency is augmented by existing entrepreneurial capacity, which makes such knowledge *firm-specific*, as in Ehrlich et al. (1994), as well as by institutional factors (*I*) and the entrepreneur's general educational attainments (*h*), that we elaborate on below. This property of EHC production abstracts from any issues concerning rivalry or cooperation across enterprises, which is consistent with the assumed competitive nature of the market for goods. The fact that the production of new knowledge is linear with respect to accumulated knowledge also implies that new knowledge production is not subject to diminishing returns, as is the case with investment in knowledge in general. This makes EHC a *distinct* engine of self-sustaining perpetual growth.

The share of the enterprise's production capacity invested in the production of new entrepreneurial knowledge, $\varepsilon(t)$ ($\in [0, 1)$), is the critical variable determining the pace of EHC accumulation and thus economic growth. If $\varepsilon(t) = 0$, no effort is devoted to EHC accumulation and the economy is in a stagnant equilibrium of the standard neo-classical form, in the sense that the growth rate of *per-capita* output is zero, i.e., $g^* = 0$. However, $\varepsilon(t)$ must be less than 1 to secure a positive production and growth of goods' output along the economy's balanced growth path.

The magnitude of $\varepsilon(t)$ also distinguishes between two types of entrepreneurial activities: managerial and innovative. Managerial activities focus on utilizing current resources to enhance current production, sales, and profits. Innovative activities are driven by innovative ideas. Innovative entrepreneurs work as intermediaries between the market for goods and the market for ideas by discovering or absorbing basic technological innovations and turning them into new production processes or new products. To accomplish this intermediation task, they allocate a greater fraction of their own time or the enterprises' resources toward research and development and marketing efforts to discover and translate the basic technological breakthroughs into process and product innovations consumers truly desire. These efforts ultimately enhance future production and sales – even at the expense of losing current sales and profits.[3]

Equation (2) also implies, that the production of new knowledge is augmented by both institutional factors and personal characteristics of the entrepreneur. Institutional factors, such as democracy, protection of freedom of thought, speech, and other individual liberties and intellectual property rights are essential for the promotion of a free market for ideas. The market for ideas flourishes in most democratic countries but is harshly suppressed in most non-democracies (Coase and Wang, 2012). Institutional factors, such as the rule of law, place limits on government power and control of private economic activity where freedom of individual mobility, trade, and exchange are essential for promoting free market for goods. Critical personal characteristics that improve the productivity of investment in entrepreneurial knowledge include innate cognitive and non-cognitive ability as well as a sufficient level of knowledge that enhances the entrepreneur capacity to translate existing or advancing general scientific knowledge to new goods or production processes - and thus serve as an effective intermediary between the market for ideas and the market for goods, using Coase's (1974) terminology.

The decision rule and optimization analysis:

Each agent maximizes the lifetime utility by deciding on consumption c(t) in real term, which represents a stream of units of a single good over the agent's infinite horizon. Preferences over per-capita consumption streams are given by

(3) $$\int_0^{\infty} e^{-\rho t} \frac{1}{1-\sigma}[c(t)^{1-\sigma} - 1]\,\mathrm{d}(t)$$

In equation (3), ρ is the discount rate and σ is the coefficient of (relative) risk aversion. Both are assumed to be positive.

Using equations (1a)-(3), the current-value Hamiltonian can be stated as follows:

(4) $$v(k, E, \theta_1, \theta_2, c, \varepsilon, t) = \frac{1}{1-\sigma}\left(c^{1-\sigma} - 1\right) + \theta_1 \left\{Ak^{\beta}\left[E(1-\varepsilon)\right]^{1-\beta} - c\right\} + \theta_2 IhE\varepsilon$$

where θ_1 (t) and θ_2 (t) are the shadow prices of investments in physical and entrepreneurial capital respectively. The basic control variables in this model are thus consumption, c (with the indirectly determined savings representing investment in physical capital) and investment in entrepreneurial capital, ε(t).

The first-order optimality conditions for c and ε, respectively are thus:

(5) $$c^{-\sigma} = \theta_1$$

(6) $$\theta_1 (1-\beta) Ak^{\beta}\left[E(1-\varepsilon)\right]^{-\beta} = \theta_2 Ih$$

The rates of change of the shadow prices of physical and entrepreneurial capital θ_1 and θ_2 , respectively, are given by

(7) $$\dot{\theta}_1 = \rho\theta_1 - \frac{\partial v}{\partial k} = \rho\theta_1 - \theta_1 \beta Ak^{\beta-1}\left[E(1-\varepsilon)\right]^{1-\beta}$$

(8) $$\dot{\theta}_2 = \rho\theta_2 - \frac{\partial v}{\partial E} = \rho\theta_2 - \theta_1 (1-\beta) Ak^{\beta}(1-\varepsilon)^{1-\beta} E^{-\beta} - \theta_2 Ih\varepsilon$$

In a steady state of balanced growth equilibrium, the growth rates of per-capita output, consumption, physical capital, and EHC are equalized at the explicit common value:

(9) $$\frac{\dot{q}}{q} = \frac{\dot{c}}{c} = \frac{\dot{k}}{k} = \frac{\dot{E}}{E} = \frac{Ih-\rho}{\sigma} \equiv g^{*},$$

where g* represents the equilibrium growth rate of per-capita income as well.

Inserting the entrepreneurial capital accumulation function (2) into equation (9), we can derive an explicit solution for the balanced-growth equilibrium rate of investment in entrepreneurial human capital as well:

$$(10) \quad \varepsilon^{*} = \frac{1}{\sigma}(1 - \frac{\rho}{Ih})$$

In these explicit solutions of the model, the growth rate of per-capita income g* and the optimal rate of investment in entrepreneurial human capital, ε*, are the central endogenous outcomes of the model, on the assumption that the underlying institutional and general education parameters, I, h, σ and ρ are exogenous or predetermined variables.

From the explicit solutions for the equilibrium long-term growth rate of output and the investment rate in EHC, we can derive the following propositions:

Proposition 1*: The economy can join a regime of persistent growth if, and only if, the institutional factors supporting a free market for ideas and the innovating entrepreneurs' endowed human capital exceed individual time preference: $Ih > \rho$. In that case, the steady state investment in EHC is higher the lower is the innovative entrepreneurs' coefficient of relative risk aversion, σ.*

The proposition follows directly from equations (9) and (10). Since in equilibrium,

$\varepsilon^{*} = \frac{1}{\sigma}(1 - \frac{\rho}{Ih})$, for ε* to be positive, so the economy can reach a persistent growth regime, it is necessary that the product of the efficiency parameters *I* and *h* would be positive, such that it exceeds the time preference parameter, or $Ih > \rho$.

A corollary to proposition 1 is that a sufficient level of institutional reforms and general education supporting free markets for ideas and goods can trigger a takeoff from a stagnant regime to a persistent, self-sustaining growth regime (see Ehrlich and Lui, 1991).

Proposition 2*: The institutional factors and entrepreneurs' own educational attainments enhance the steady-state investment in entrepreneurial capital***.**

$$(11)\quad \frac{\partial \varepsilon^*}{\partial I} = \frac{\rho}{\sigma h I^2} > 0; \qquad \frac{\partial \varepsilon^*}{\partial h} = \frac{\rho}{\sigma I h^2} > 0;$$

$$\frac{\partial^2 \varepsilon^*}{\partial I \partial h} = \frac{\partial^2 \varepsilon^*}{\partial h \partial I} = -\frac{\rho}{\sigma (Ih)^2} < 0; \qquad \frac{\partial \varepsilon^*}{\partial (Ih)} = \frac{\rho}{\sigma (Ih)^2} > 0.$$

The implications of equation set (11) are that the allocation of investment in EHC to innovative, relative to managerial entrepreneurship (ε^*) is a non-linear function of the entrepreneurs' own educational attainment (h) and the underlying institutional factors (I) which empower the markets for ideas and goods. While the partial impacts of a change in I or h, or of the product of the two (Ih) on ε^* are positive, however, the impact of the change in I on ε^* diminishes with h, and the impact of the change in h on ε^* diminishes with I. This is essentially the result of diminishing marginal utility from allocating more current resources to investment in EHC relative to current consumption, and the assumption that I and h are complementary in their impact on ε*.

Proposition 3*: A rise in the equilibrium level of persistent rate of investment in entrepreneurial capital has an ambiguous effect on output level over a transitional period, but an enhancing effect on the equilibrium endogenous growth rate of output.*

Using the firm's production function for goods (equation 1a) and the solution for the optimal rate of investment in EHC (equation 10), we obtain the following effect of ε on output level:

$$(12)\quad \frac{\partial q(t)}{\partial \varepsilon(t)} = (1-\beta)q(t)[Iht - \frac{1}{1-\varepsilon(t)}]$$

The effect of investment in entrepreneurial capital ε* on the representative firm's output *level* is ambiguous. It may be negative over a relatively short time span when the economy is on the transition path leading to a steady state of growth following the upward shift in ε*(t), but it becomes positive over a sufficiently longer time span as the catch-up effect from a higher equilibrium growth rate kicks in. In the steady state of balanced growth we have:

$$(13)\quad \frac{\partial \hat{q}}{\partial \varepsilon} = \frac{\partial \hat{E}}{\partial \varepsilon} = Ih > 0,$$

where $\hat{q} = \frac{\dot{q}}{q}$ and $\hat{E} = \frac{\dot{E}}{E}$.

The effect of investment in entrepreneurial capital on the growth *rate* of output is thus positive along the economy balanced growth path, with the growth rate g*, as defined in equation (9)

The implication is that economies in which entrepreneurs devote more resources into innovative activities which expand future production achieve a higher rate of economic growth than economies in which entrepreneurs devote more of their resources to enhance current production. In the short run this may result in a lower *level* of economic growth. In the long run, however, a higher rate of growth wins, so economies with a higher rate of innovative investments in EHC achieve both a higher level and rate of endogenous economic growth.

4. Empirical Implementation

We test the basic propositions of our model against comprehensive international panel data described in section 4.1. The results of the corresponding regression analyses and related robustness and corroborative tests are presented in section 5.

4.1 Data and key variables

The data used in the empirical estimation come from five main sources: Global Entrepreneurship Monitor (GEM), the Index of Economic Freedom, Penn World Tables (PWT), Barro-Lee (2010), and World Bank World Development Indicators. Variables are extracted from these sources to form two unbalanced panels: one containing 17 countries with 2 to 9 years of data over the period 2002-2010, and a larger panel containing 63 countries with 1-9 years of data over the period 2002-2010. Summary statistics of key variables are given in Table 1.

Investment in entrepreneurial capital (INVEC)-proxy for epsilon (ε). The theoretical measure of this key variable is the share of the representative firm's production capacity or working time allocated to innovative activities, but such comparable data are not available internationally. Instead, we measure *INVEC* as the fraction of innovative entrepreneurs among all entrepreneurs, using the data reported in the Global Entrepreneurship Monitor (GEM)'s adult population longitudinal surveys.[4] GEM reports counts of three types of entrepreneurs: nascent entrepreneurs who start up new businesses, new business owners, and established business owners. In GEM's survey, these entrepreneurs are asked to provide an assessment of the novelty or unfamiliarity of their products or services relative to customers' current experience. We identify as "innovative" those entrepreneurs who claim that the products or services they offer are new to some or all customers. This distinguishes entrepreneurs who are more engaged in, and allocate more of their own time and company's production capacity to innovative activities. *INVEC* can thus be viewed as a proxy of the economy-wide or representative entrepreneur's share of the total enterprise's productive capacity invested in innovative rather than managerial activities.

While *INVEC* may not be an ideal measure of our theoretical measure of investment in EHC (ε), we try to test its empirical relevance by the degree to which it can be predicted by the two underlying factors that are expected by our model to influence its level: the general human capital (higher education) attainment of the representative entrepreneur and the institutional factors that support a free enterprise system that also assures the role of entrepreneurs as intermediary between the market for ideas and the market for goods – our theoretical h and I factors in equation (2).

Entrepreneurs' human capital endowment-proxy for h. The theoretical proxy for h is the entrepreneur's endowed educational attainment. There are however, several ways to measure this proxy empirically. By our model's logic, we perceive of especially the innovative entrepreneur's role as an intermediary between the market of ideas (general knowledge or basic science) and the market for goods. It is then plausible to choose the higher educational attainments of entrepreneurs as an efficient proxy for h.

In the GEM Adult Population Survey, entrepreneurs are asked to identify their educational background in one of four categories: some secondary education; completed secondary education;

post-secondary education; and graduate experience. We choose the percentage of entrepreneurs attaining the top education category – those with graduate experience *ENTGRAD* – as the more appropriate measure of h. The rationale is that this measure captures primarily those entrepreneurs who would be more inclined to allocate resources to innovative relative to managerial activities. Alternatively, since by our model the representative entrepreneur also leads the representative firm, we also use the percentage of adult population age 25 years and over who have a college degree, POPCOLL, as a wider measure of tertiary education. This measure captures, in principle, the educational attainment of the entrepreneur's team of workers and managers as well. Barro and Lee (2010) report such measures over five-year spans. We therefore derive the yearly equivalents through an interpolation that assumes a constant growth rate**.** Since *ENTGRAD* is reported in GEM only for countries in our small sample, we resort to POPCOLL as a proxy for our theoretical *h* in our large sample regressions.

Institutional support index (INSTALL)-proxy for I. As mentioned earlier, institutional pillars such as freedom of trade and exchange and protection of property rights are preconditions for successful free markets as well as productive investments in both physical and human capital. The rule of law, freedom of speech and protection of intellectual property impose a limit on government intervention in the market for ideas, while protection of physical property rights, labor mobility, and free access to markets limit government intervention in productive private economic activity. The institutional factors which enhance the efficiency of the market for ideas, however, also enhance the efficiency of the market for goods and vice versa. We therefore select an overall economic freedom score (*INSTALL*) as a proxy for our theoretical institutional construct, I. This measure is drawn from the Index of Economic Freedom, composed by the Wall Street Journal and the Heritage Foundation to measure the degree of economic freedom among countries in the world. The score used, ranging from 0 to 100, is the simple average of the scores of 10 individual freedom indexes, which are grouped into four categories: a. Rule of Law: property rights and Freedom from corruption; b. Limited government: fiscal freedom and government size/spending; c. Regulatory efficiency: business freedom, labor freedom, and monetary freedom; d. Trade freedom, investment freedom, and financial freedom. Since we treat institutional measure as a predetermined variable in the model, we use the *initial values* of INSTALL in our regression analysis.[5]

Real per capita output and income – a proxy for q. As is conventional, we use real GDP per capita (*RGDPPC*) as the measure of the *level* of per-capita real income. The data for *RGDPPC* are drawn from the Penn World Tables (PWT) 8.0.

Total Factor Productivity (TFP). This variable is used as an alternative indicator of real per-capita income, constructed as $TFP = q/ k^{\alpha} l^{1-\alpha}$, where q, $k = K/L$, and l are measured as real GDP per worker, capital per worker, and human capital per worker, respectively. Human capital per worker is measured as the average years of schooling of the population aged 15 and over. The underlying production function is the Cobb-Douglas specification of constant returns to scale, with the capital share α assumed to be 0.3. These variables are taken from the Penn World Tables (PWT) 8.0.

Exogenous and predetermined environmental factors, proxies for V in equation (1a). We specify a number of such assumed exogenous environmental factors:

-*Initial average years of schooling attained by the population aged 15 and over in 2000* ($POPEDYRS_0$) is used to proxy the overall human capital endowment of a country. The data are drawn from Barro-Lee (2010). The subscript 0 denotes the initial values.

-*Initial real GDP per capita* ($RGDPPC_0$) to capture the stage of development of the different countries in the sample.

-*The economy's initial capital to labor ratio* $(K/L)_0$ is also entered as a control variable reflecting the economy's level of development in the production of good (see equation 1a).

-*Government size (GOV)* is measured by government spending as a percentage of GDP.

-*Openness (OPEN)* is measured by the volume of external trade (Imports+Exports) as a percentage of GDP. Although our model is developed within a closed economy setting, we introduce the economy's degree of openness to trade as another indicator of its level of development. Both GOV and OPEN are drawn from PWT 8.0.

- *Regional and year dummy variables.* These are discussed in section 4.2

Flow measures of alternative educational investments used as relevant controls variables in our "corroborating" diagnostic tests. These tests are designed to pit the impact of investment in entrepreneurial human capital as an engine of growth against the impacts of conventional measures of investment in general human capital that have been modeled in the literature as underlying engines of growth. To account for investment in general human capital, or its stock measure we use initial values of TER-ENROL, representing total enrollment in tertiary education as a percentage of the population of the corresponding official tertiary education age groups, and TER-YRS, representing the average years of tertiary schooling attained by population aged 15 and over in 2000.

Table 1 shows the definitions and summary statistics of the key variables used in the regression analysis. In the small sample, the share of entrepreneurs identifying themselves as innovative (*INVEC*) has an average value of 42.5% with a standard deviation of 14%, which indicates that only a fraction of entrepreneurs are innovative types. The average of the overall institution score is 69.509, and about 6.6% of the entrepreneurs have some graduate school experience. In the large sample, by contrast, *INVEC* has a lower average value (38% with a standard deviation of 15%), as does the average of the overall institution score (66.555), and the average share of the adult population age 25 and over who had college degree is 12.7%. The average values of all other key variables – measures of per capita income, educational attainment, capital-labor ratio, and productivity – listed in Table 1 are greater for the small sample than for the large sample, with the exception of the measures of openness and relative size of the government. The difference in all of these averages stems from the fact that the large sample contains more developing countries.

4.2 Empirical strategy

Our theoretical treatment of both entrepreneurship and long-term growth as endogenous variables has yielded testable implications summarized in propositions (1-3) concerning the determinants of investment in EHC and its impact on the economy's dynamic growth paths. In our *baseline econometric model* we test these propositions via a two-step recursive system.

The first step specifies the investment in entrepreneurial capital as a function of the institutional factors that support the free flow of ideas between the market for ideas and the market for goods, as well as the entrepreneurs' general human capital endowment, measured by their higher education experience. Indicators of higher education are especially relevant as an enabling factor for the intermediating services rendered by innovative entrepreneurs and entrepreneurial human capital. The higher education experience of the labor force or the population as a whole may also be relevant in this context, capturing the higher education level of the enterprise's employees, although not to the same extent as that of the higher education experience of entrepreneurs.

Following equation (11) and proposition 2, we specify the investment in entrepreneurial capital function in country *i* at time *t* by the following baseline linear regression equation:

$$(14) \quad INVEC_{it} = \alpha_1 INSTALL_{i0} + \alpha_2 ENTGRAD_{i0} + \alpha_3 INSTALL_{i0} * ENTGRAD_{i0} + \alpha_4 X_{i0} + v_r + z_t + e_{it},$$

where *INVEC* represents the representative entrepreneur's investment in entrepreneurial capital, approximated by the share of innovative entrepreneurs among all entrepreneurs; INSTALL_0 is the initial value of the institutional variable, and ENTGRAD_0 is the initial share of entrepreneurs with graduate experience or, alternatively, the share of the general population age 25 and over with college education. The reliance on initial values of *INSTALL* and *ENTGRAD* is intended to avoid a regression bias due to the possible simultaneity relation between investment in EHC and these variables, which is not part of our model, but which could be justified due to the influence of rising rates of investment in EHC on the incentive to acquire higher education or demand institutional safeguards guaranteeing a market return on educational investments.[6]

Note that we add in this specification an interaction term between the institutional and educational variables, since by equation (11), the marginal impact of each of these variables on optimal investment in EHC is expected to be crowded out by an increase in the other variable. We also account for cross-country heterogeneity in the economy's level of development and the population's human capital endowment using the initial values of real GDP per capita ($GDPPC_0$) and average years of schooling of the population over 15 years of age ($POPEDYRS_0$). These variables are contained in the vector X_{i0} in equation (14).

We should point out that because equation (14) relies on initial values of the regressors, we cannot employ country-specific fixed-effects models. Instead, we group countries into seven economic regions (following the Penn World Tables) and introduce region dummies, v_r, to control for common characteristics that countries in the same region may share.[7] The term z_t represents a set of year dummies to account for year-specific shocks that are common to all countries, and e_{it} is the random error term.

The second step of the recursive system establishes the causal relationship between investment in entrepreneurial capital and the steady-state growth rate of per capita income. By proposition 3, economies in which entrepreneurs invest more resources on innovative projects achieve a relatively steeper balanced growth path, and eventually a higher level of per capita income as well. In the short term, however, such investment may have a mild or even negative impact on output level because the investment in entrepreneurial capital crowds out spending on managerial and production work, as indicated by equation (12) and proposition 2.

To capture the long-term or steady-state relationship between our proxies for investment and growth is challenging because (1) most economies are likely to be in transition to, rather than in a steady-state of growth equilibrium, and (2) data are available for only a relatively short period – just over nine years. To overcome these constraints, we test propositions 2 and 3 by implementing the following regression model, which allows for the estimation of both the level and the long-term growth effects of investment in EHC, while also accounting for the economy's stage of development: [8]

(15) $LRGDPPC_{it} = \beta_1 INVEC_{it} + \beta_2 T{*}INVEC_{it} + \beta_3 T + \beta_4 Z_{i0} + \beta_5 W_{it} + v_r + u_{it}$,

where L is the log operator, $RGDPPC_{it}$ is real GDP per capita, T is a time trend, Z_{i0} is a vector of variables capturing country-specific stages of development (see section 4.1) ($LRGDPPC_0$, $POPEDYRS_0$, $L(K/L)_0$), W_{it} is a vector of variables including some country-specific and time varying policy factors that may affect the economy's income level (*OPEN*, *GOV*), v_r is a variable for regional fixed effects, and u_{it} is a random error term. Parameters β_1 and β_2 are of primary interest in this analysis. They measure the effects of a one-unit increase in the representative entrepreneur's investment in EHC on the level and long-term growth rate of real GDP per capita, respectively. To the extent that β_3 captures the average growth rate of all economies, β_2 can be interpreted as the effect of investment in EHC on the steady-state balanced growth path.

Our baseline model – the recursive system specified by equations (14) and (15) – allows for estimating the impact of investment in EHC on the growth path via ordinary least squares (OLS). To test the consistency of the estimated regression coefficients, however, we also attempt to account for a potential reverse causality running from exogenous short-term changes in output per-capita to a contemporaneous change in investment in entrepreneurial human capital, since a short-term change in the level of *RGDPPC* that raises expectations of future growth could accelerate the short-term demand for investment in EHC. In that case, estimating equation (15) by the OLS method would result in inconsistent coefficient estimates.

We address this concern in three ways. First, we estimate an expanded version of equation (14) using the initial values of the institution and human capital of entrepreneurs and other exogenous or predetermined factors specified in our recursive model to generate the predicted values of entrepreneurial capital investment, *INVEC**, which is then entered directly into equation (15) in place of *INVEC*. The second method for purging a potential simultaneity bias is to use the predicted investment variable *INVEC** and its interaction with the time trend *T*INVEC** as instrumental variables (IVs) to obtain consistent estimates of the effects of *INVEC* and T*INVEC in equation (15). The third method is the standard 2SLS estimation method. Instruments used in this method include the initial values of the measures of institutional environment, the human capital endowment of entrepreneurs, the interaction term of the latter two, and the interaction terms of these three variables with the time trend, or a total of six IVs.

5. Empirical results

The estimated equations (14) and (15) are presented in sections 5.1-5.3. In section 5.4 we conduct a robustness test of our model by using total factor productivity (*TFP*), instead of real per-capita GDP (*GDPPC)* to see if the main pattern of the results of the regression analysis holds up in this case as well. In sections 5.5 and 5.6 we also conduct a series of discriminating/diagnostic tests of our central hypothesis corroborating the role of entrepreneurial human capital investment as a specific independent driver of endogenous growth.

5.1 Estimating the investment function via the first step of the recursive model

As required by the specification of the first step of our recursive model, we estimate equation (14) by regressing *INVEC*, our proxy for investment in EHC, on the initial values of the institution indicator (*INSTALL)* and human capital endowment of entrepreneurs (*ENTGRAD*) to avoid any simultaneity biases. A potential downside of using initial values is that the estimates depend exclusively on cross-country variations in the corresponding variables. But, since we are working with a relatively short time series, between-country estimates can perhaps better approximate the steady-state relationship between *INVEC* and *INSTALL* and *ENTGRAD* on the one hand, and *INVEC* and *RGDPPC*, on the other. Table 2 presents the OLS estimates along with heteroscedasticity-robust standard errors.

In columns 1 and 2, the initial years are 2000 and 2002 for the institution indicator and entrepreneur's human capital, respectively. To account for the fact that our sample's countries are in different stages of economic development, we also include per capita income in 2001 and average years of schooling in 2000 as controls in column 2. The estimates are all positive and statistically significant at the 1% level, which are consistent with the predictions of proposition 2. Countries with stronger institutions or better-educated entrepreneurs are shown to invest more in entrepreneurial human capital. The negative effect of the interaction term *INSTALL*ENTGRAD* is also consistent with proposition 2 - the positive impact of the institution variable diminishes with the higher educational attainment of entrepreneurs, and vice versa.

The use of initial values of the two key variables eliminates many countries from our sample because of missing values of *INSTALL* in the sample's initial year. The small size of the sample (116) is also due to the educational attainment of entrepreneurs *ENTGRAD* being available from GEM only for this small sample. To allow for the expansion of the sample, we change the regression specification in two ways. First, we use an alternative proxy for the human capital attainment – the share of college educated workers in the general population aged 25 and over, *POPCOLL*, which is reported for more countries in the sample than *ENTGRAD*. Second, we treat the "initial year" of the sample as the "first year of the sample" in which the institution measure (*INSTALL*) and the entrepreneur's human-capital measure (*POPCOLL*) are both available from their respective sources. As noted in section 4.1, *POPCOLL* can be justified as a measure of entrepreneurs' higher education on the grounds that it captures the educational attainment of the representative *enterprise*, which includes the entrepreneur's work force as well. The college-educated share of the population and that of the representative entrepreneur are highly correlated: the simple correlation coefficient is 0.62.

This alternative specification of the recursive model helps expand the sample size from 116 to over 300, though the newly added countries have slightly shorter time series. The estimates based on this specification of equation (14), reported in columns 3 and 4, are also statistically significant and with signs conforming to proposition 2. One noticeable change is that the estimated effect of the human capital endowment is considerably smaller than that of their small sample counterparts in columns 1 and 2. But this is consistent with the logic of the model since investment in entrepreneurial human capital should be more strongly enabled by the human capital endowment of the entrepreneurs than by that of the firm's workers. The same pattern applies to the estimates associated with the institution index, which become smaller in the regressions using the expanded sample. The fact that the estimated effects of both key variables are statistically significant but smaller quantitatively in the expanded sample (this pattern appears in the growth regressions as well) is consistent with our theoretical expectations. It also suggests that the findings are not primarily driven by a subset of countries with longer time series, which tend to represent developed, rather than developing economies.[9]

We repeat the regressions corresponding to columns 1 through 4, in columns 5 through 8, after replacing year dummies with a time trend. We do this for two purposes. One is to check the sensitivity of our main estimates to alternative specifications for capturing the passage of time effect. The estimates reported in columns 5 through 8 do not exhibit any remarkable changes when we include a time trend in the regression instead of year effects. The other purpose of using the time-trend specification is to see whether the data we have on our investment in EHC proxy could approximately represent steady-state values, as implied by proposition 1. A necessary, albeit not sufficient, condition for the steady state is that equilibrium level of investment does not vary over time. This may be one reason why the average time trend effect in these regression is insignificant.[10]

5.2 Estimating the level and the long-term growth effects of investment in EHC on per capita income via the second step of the recursive model

Table 3 presents the estimated regression coefficients of equation (15) as the second step of a recursive model. In all these regressions we include real GDP per capita and the average years of schooling (for population over 15) in 2001 and 2000 respectively to control for cross-country differences in levels of development. These controls are important because most countries are in different stages of development and thus in different phases of transition to a growth equilibrium, rather than in the steady state of balanced growth as assumed in our theoretical analysis. The transition dynamics, in turn, depend on the initial conditions of each individual economy. We also add the initial-year capital to labor ratio as an additional measure of the economy's proximity to a steady state of a balanced growth equilibrium. To take into account the potential effect of other "environmental" factors affecting the level of per-capita income along the economy's balanced equilibrium growth path, we consider two time-varying policy variables: trade and the size of government. The former is measured as openness – the country's volume of trade as a share of GDP. The latter is measured by government spending as a share of GDP.

The regressions in columns 1 and 2 use our constructed measures of investment in EHC and its interaction term with the time trend to derive the level and growth effects of *INVEC*, based on the small and large samples, respectively. Overall, the estimated coefficients associated with the short-term "level effect" of investment in entrepreneurial human capital (*INVEC*) are negative (albeit not always statistically significant), as would be predicted by equation (12) for economies in an early stage of transition to a growth regime. The estimated effects of entrepreneurial capital investment on the growth rate of per capita income, by contrast, are positive and statistically significant at the 1% level, as predicted by equation (12) and proposition 2. The estimated rate-effect of *INVEC* based on the small sample is quantitatively larger than that based on the large sample. But statistically, they are hardly distinguishable. These estimates suggest that a ten-percentage-point increase in INVEC could raise the growth rate of per capita income by one-half to six-tenth of one percentage point.

However, the straight OLS estimates reported in columns 1 and 2 might suffer from simultaneity bias, as we noted in section 4.2: an upward change in economic growth raises the return to innovation and consequently it might induce more short-term investment in entrepreneurial capital.

One way to address this concern is to use the predicted, rather than the actual, investment in EHC. We obtain the predicted investment using two methods. By the first method, we derive the predicted value from the models underlying columns 2 and 4 in Table 2. This method takes advantage of the recursive model's structure by which the potentially interrelated variables, namely investment in entrepreneurial capital and per capita income, are determined sequentially rather than jointly. Given that all the explanatory variables included in the investment regressions are initial values, the predicted investment is unlikely to be correlated with the error term in the per capita income regressions. By the second method, we use a reduced form approach to generate the predicted investment values. The reduced form regression involves two modifications in equation (14). First, we replace the year dummies with a time trend, as in the models reported in columns 5 through 8 of Table 2. Second, we add to the reduced form equation all the exogenous variables contained in equation (15), including the capital-labor ratio, as well as measures of openness and size of the government.

The estimated coefficients of equation (15) based on the alternative *predicted* investments are reported in columns 3 through 6 of Table 3. Whereas the estimated level effects remain negative, the growth-effect estimates are quantitatively larger than their OLS counterparts in columns 1 and 2. The growth-effect estimate based on the small sample is not sensitive to the alternative ways by which the predicted investment in EHC is generated – recursive or reduced form specification. But the reduced-form approach does lead to an improvement in both the magnitude and precision of the estimated growth-rate-effect when the large sample is used. Based on the column 6 results, a ten-percentage-point increase in the share of innovative entrepreneurs could raise the growth rate of per capita income by as much as 1.1 percentage points.

5.3 Instrumental variables estimates of the level and long-term growth effects of *INVEC*

We also use the instrumental variables method to test for the potential simultaneity bias discussed in section 4.2 and the preceding section. A straightforward IV approach, in which both the investment variable and its interaction with the time trend are treated as endogenous variables in equation (15), would involve six instruments: institution index, human capital endowment of entrepreneurs, an interaction term between the latter two variables, and three time-interaction terms between each the above variables and the time trend. These IV estimates are presented in columns 1 and 2 of Table 4. The estimated level effect of *INVEC* remains negative and not always statistically significant. And although the estimated growth effect is still positive, the precision of the latter is much reduced. In fact, the 2SLS estimate of the growth effect is not statistically significant when either the smaller sample or the larger sample is used. However, the Sauderson-

Windmeiler multivariate F-test of the excluded instruments indicates that the IVs as a group are weakly correlated with INVEC and T*INVEC, and as a result the IV estimates are subject to a weak IV bias – the F test statistics in the reduced form regressions for INVEC and T*INVEC are 5.00 and 3.46, respectively, based on the small sample, and 1.68 and 1.83, respectively based on the large sample. The Kleibergen-Paap tests also suggest that the IVs are weak. This is not surprising because the identification power of these IVs is greatly diminished by the relatively high correlations among them. More important, the Hausman endogeneity (chi-squared) tests fail to reject the null hypothesis that INVEC and T*INVEC are exogenous, as indicated by the test statistics 2.703 and 4.096 associated with the corresponding regression models. This indicates that instrumenting these variables is superfluous, and it may significantly increase their standard errors, relative to those of the OLS estimates.

To further explore the endogeneity issue, we adopt an alternative approach which involves an extra step to generate IVs for the endogenous variables INVEC and T*INVEC before implementing the standard 2SLS procedure. In this approach, we first use the full reduced form, comprised of all the exogenous and predetermined variables associated with equations (14) and (15), to predict the investment variable, *INVEC**, which we then multiply by the time trend *T* to construct the interaction term *T*INVEC**. We can thus use these predicted variables as IVs for INVEC and T*INVEC to obtain IV estimates of the coefficients of equation (15). These estimates are reported in columns 5 and 6 of Table 3.[11]

These predicted reduced-form variables appear to constitute strong IVs, as evidenced by the relatively large values of the Sauderson-Windmeiler multivariate *F* tests: 17.65 and 57.95 from the reduced form regressions for INVEC and T*INVEC respectively, based on the small sample, and 10.03 and 30.88 respectively based on the large sample.[12]

The estimated level effect of INVEC is negative, and is even statistically significant in column 3 of Table 4, based on a reduced form containing the initial value of the entrepreneur's higher educational attainment *ENTGRAD*, rather than that of the total population *POPCOLL* in column 4, while the estimated rate effects based on both samples is positive and statistically significant at the 1% level in both columns. However, the test statistics obtained by applying the Hausman endogeneity tests in the regression models of columns 3 and 4 – 7.296 and 3.683, respectively – imply that the null hypothesis of exogenous INVEC and T*INVEC is rejected in column 3, based on the small sample model, but not in column 4, based on the large sample. These tests indicate that the IV method may be regarded as relevant for deriving valid estimates of the regression model of column 3, but that no instrumentation is needed to estimate the regression model of column 4 in Table 4 in preference of the OLS estimates of this model in columns 2 and 6 of Table 3.

Our inference from the IV estimates of Table 4 is that they are inconclusive due to both the weak IVs used to instrument the investment variable INVEC and its interaction term with the time trend T*INVEC, as well as the apparent lack of consistency of the endogeneity test across our two samples. The one run (in column 3 of Table 4) that is free of the weak-IV bias and in which the Hausman test rejects the exogeneity of INVEC and T*INVEC in equation (15) yields estimates of the level and rate effects of INVEC and T*INVEC that are very similar to the estimates we drive for the effects of these variables using the OLS method in column 5 of Table 3.

More generally, all the IV estimates of especially the rate effect of INVEC on per capita income in columns 1 to 4 of Table 4 are in the same ballpark as their OLS counterparts in columns 3 to 6 of Table 3, where the predicted INVEC* enters the regressions in place of the observed INVEC: all indicating an increase in the rate of growth of GDP around 1% when investment in entrepreneurial human capital rises by around 10%. In terms of statistical inference, the OLS results are as valid in column 5 of Table 3, as they are in column 3 of Table 4, while the estimates obtained from column 6 of Table 3 and column 4 of Table 4 are virtually the same, indicating that the baseline recursive model produces reliable estimates. For this reason, we will perform robustness checks and diagnostic tests in the following section using the OLS estimation method.

5.4 Robustness checks: estimating the level and rate effects of *INVEC* on *TFP*

In this section we switch the dependent variable in equation (15) from real per-capita income to total factor productivity (*TFP)* as a robustness test of the results of Table 3, since growth in TFP should be highly correlated to that of *RGDPPC*. Since the specification of the first step of our recursive model is essentially the same in both cases, we focus in this section on the estimation of the second step of the model, where the log of TFP (*LTFP*) becomes the dependent variable of relevance. The only modification is that the initial level of *LRGDPPC* is replaced by the initial level of *LTFP* in all first-stage or reduced-form regressions, which we use to predict *INVEC**, while *LRGDPPC* remains the relevant control variable in the second-stage regression model which we use to estimate the effect of *INVEC** on the level and growth rate of *TFP*.

Tables 3A and 4A present the second-stage regression estimates of the modified equation (15) with *LTFP*, rather than *LRGDPPC* serving as dependent variable, which correspond to the results in Tables 3 and 4. Notably, the qualitative results in these tables confirm all the counterpart estimates in Tables 3 and 4. The only notable difference is that the estimated rate effects of the investment variable, *INVEC* are lower in Tables 3A and 4A relative to their counterparts in Tables 3 and 4. This may not be surprising since TFP is a constructed dependent variable, based on a restricted specification of the production function of output per worker (see section 4.1) which does not account for any of the external environmental factors entering equation (15) in Tables 3 and 4 (although these variables do enter the second-stage regression equations as regressors).

It is also notable that the tests for weak IVs and the presence of endogeneity in table 4A yield test statistics and inferences which are similar to those in table 4, where *LRGDPPC* serves as the dependent variable. The null of exogenous INVEC and T*INVEC cannot be rejected only when the alternative IV approach is applied to the small sample, which is also the only model in which the IVs are strong.

5.5 Corroborating diagnostic tests of the independent effect of *INVEC* on level and rate of growth of real per-capita income.

Equations (14) and (15), as well as the regression analysis reported in sections 5.2-5.4 implicitly assumes that the only way that institutional factors and the human capital endowments of entrepreneurs increase the growth rate of per capita income is through their influence on the critical theoretical construct in our model - investment in entrepreneurial human capital (ε) or its empirical counterpart (*INVEC*). However, if the institutional and general education factors exert independent, and possibly dominating effects on the growth rate, the positive rate effect we ascribe to investment in EHC may be spurious. To explore this issue, we expand the regressions where real income per-capita (GDPPC) serves as dependent variable to include the institution and human capital endowment of entrepreneurs *in addition* to *INVEC**, thus allowing these former variables to directly affect the level and growth rate of per capita income.

As the estimates reported in column 1 of Table 5 based on the small sample results indicate, increases in the institutional index level and the general human capital level of entrepreneurs (*ENTGRAD*) by themselves (excluding the effects of INVEC*) are actually found to exert a negative impact on the growth rate, and in the case of *ENTGRAD* significantly so. Similar results are obtained in columns 2 and 3 of Table 5, where we also enter the observed INVEC and T*INVEC or their predicted values to the regression models, using the small sample.

Columns 4 through 6 repeat the regressions in columns 1 through 3 using the large sample. In both sets of regressions we enter our key theoretical variable *INVEC* along with the institutional and general human capital variables as regressors, to test whether *INVEC* will continue to exert an independent and statistically significant effect on the growth rate of real GDP per-capita over and above that of the institution and general human capital, which by our theoretical model serve as efficiency variables that augment INVEC's effect. The results indicate that this is indeed the case. By contrast, the level and rate effects of the institutional index and the entrepreneur's higher educational attainment measures, ENTGRAD or *POPCOLL*, remain negative. Indeed, when *ENTGRAD* is used as a measure of general human capital, its effect becomes both negative and statistically significant. By these results the impacts of the underlying institutional and general human capital factors actually *vanish* when INVEC* and T*INVEC are used as regressors, while the estimated effects of the latter variables remains significant and little affected, again in line with our theoretical expectations and the recursive model we use to implement them.

Note also that the estimated growth (rate) effect of INVEC in Table 5 is always larger when the predicted *INVEC** (based on the reduced form) is used as a regressor, in columns 3 and 6, than when the observed *INVEC* is used as a regressor, in columns 2 and 5. This pattern is consistent with the one observed in Table 3, despite the fact that in Table 5 the regression specification is expanded to allow for a possible independent, if not dominating effects of our institutional (*INSTALL*) and general human capital indicators (*ENTGRAD* or *POPCOLL*). It is noteworthy that in column 6 of Table 5, the growth effect of our proxy for investment in entrepreneurial human capital *T*INVEC** is virtually the same as its magnitude in column 6 of Table 3: the comparative values are 0.104 and 0.114, respectively.

By and large these estimates warrant the following inferences. First, institution and human capital of entrepreneurs do not have a net independent positive effect on the growth rate of real per-capita income when investment in entrepreneurial human capital (*INVEC*) is accounted for as a distinct engine of growth. The level and rate effects of *INVEC* remain unaffected by the addition of *INSTALL and ENTGRAD* or *POPCOLL* and their interaction with the time trend as regressors in equation (15). Second, it thus appears that the supportive rate effect emanating from institution and human capital works *indirectly* through investment in entrepreneurial capital. Third, since in this specification we find the share of college educated individuals in the population aged 25 and over to have a positive and significant net impact on the real per-capita income level, but not on the latter's rate of growth, this suggests that one way by which general human capital affects the growth rate of real per-capita income is through its impact on investment in entrepreneurial capital – a point we further explore in the next subsection.

5.6 The growth rate effect of investment in entrepreneurial human capital vs investment in general human capital.

There is a large number of published studies on the link between human capital and economic growth using cross sectional or panel data and conventional estimation techniques (see section 2). In these studies, human capital is measured either as a flow variable, based on enrolment rates by level of education, or as a stock variable based on average years of schooling of the entire adult population or alternative educational categories. Despite systematic theoretical predictions of a positive relationship between investment in human capital and endogenous per-capita income growth, the empirical evidence has been mixed.[13]

A possible resolution of the puzzle offered by our model is that general human capital may contribute to economic growth indirectly as an enabler of the growth impact of entrepreneurial human capital, which is more directly linked to product or process innovation affecting real GDP. A related question is whether alternative general human capital measures dominate the net effect of investment in EHC, as measured by *INVEC* when we pit the former against the latter as drivers of growth.

To answer this question we estimate a series of growth regressions that allow for direct level and rate effects coming from general human capital indicators in expanded specifications of equation

(15). To do that we employ two commonly used measures of human capital: school enrolment rate (flow) and average years of schooling (stock). The estimates are presented in Table 6.

Columns 1 and 2 show the estimated coefficients of our growth regressions in our largest sample in which college enrolment rate and average years of college education of the population over 25, respectively are entered as additional regressors, in addition to *INVEC* and *T*INVEC*. In these regressions, *INVEC* is entered in its observed form. The estimated rate effects of INVEC remain positive and statistically significant at the 5% level, consistent with our theoretical expectation and in line with *INVEC*'s estimated impact when the higher education level of entrepreneurs is excluded. This indicates that the positive rate effect of investment in entrepreneurial capital is independent of any growth-rate effect associated with general human capital. By contrast, human capital, as measured by either the college enrolment rate of the population over 25 years of age, or by the average years of tertiary education, is not directly associated with higher growth rates of per capita income. In fact, human capital has a positive effect on the real per-capita income level, but a negative and statistically significant effect on the latter's rate of growth. The introduction of the flow and stock measures of the proportion of the population with higher education in the regressions summarized by columns (1) and (2) leaves the magnitude of the estimated effect of INVEC just slightly below estimates of the impact of the same *INVEC* measure shown in Table 3.

We repeat these regressions using predicted investment in entrepreneurial capital based on the reduced form equation of our recursive model (equations 14 and 15). The estimates are reported in columns 3 through 6. (In columns 3 and 4 they are based on the small sample and in columns 5 and 6 they are based in the large sample). By and large, these estimates are qualitatively similar to those in columns 1 through 2, although the estimated effect of *INVEC** in column 3 does not reach significance level. As before, predicted investment in entrepreneurial capital results in larger estimated coefficients than those associated with the observed values of these variables, while the general human capital proxies remain negative, though not always statistically significant.

Moreover, inclusion of the general higher education flow and stock measures in the large sample regressions summarized in columns 4-6 of Table 6 hardly alters the *quantitative values* of the estimated growth effects of the predicted investment in entrepreneurial human capital (*INVEC**) relative to their counterparts in columns 5 and 6 of Table 3. In all of these regressions, the estimated growth effect of investment in entrepreneurial human capital remain statistically significant and quantitatively stable within the range of about 1 to 1.2 percentage points for a 10 percentage-points increase in investment in EHC.

6. Conclusion

Our study offers a new way of looking at the impact of entrepreneurship on sustainable economic growth. The latter is generally captured by two outcome measures: real output or productivity level, and the latter's rate of growth. Entrepreneurship activity, in turn, has most commonly been associated in the voluminous literature on the topic with aggregate measures of the share of entrepreneurs in the population or the labor force. We have attempted to conceptualize the innovative aspect of entrepreneurship as a specific form of applied knowledge – firm-specific entrepreneurial human capital (EHC) – which acts as an intermediating channel connecting two "markets", using Coase's (1974) metaphor: the market for ideas (basic science) and the market for goods (new goods and production processes). We have pursued this idea by developing a stylized endogenous growth model and a corresponding econometric model in which entrepreneurial investments in EHC, measured as the share of the enterprise's production capacity allocated to innovative activities – e.g., R&D endeavours, training programs, and time and effort devoted by the entrepreneur and the enterprise's development team – directly impact the level and rate of productivity and real income growth.

To some degree, the treatment of entrepreneurship as human capital has been pursued by some previous literature we summarize in section 2. Our study's value added lies in two basic innovations. The first is our theoretical specification of the production functions of both goods and innovative entrepreneurial knowledge, along with the entrepreneur's underlying preferences, which jointly determine the equilibrium rate of accumulation of EHC and the dynamic balanced growth path it charts. Our basic innovation here is the perception of innovative entrepreneurship, or EHC, as an intermediary between the markets for goods and ideas through the translation of ideas, or basic science, into new goods and production processes and thus productivity and real income growth. In this context, we suggest that higher education and institutional factors guaranteeing a competitive return to entrepreneurial knowledge are underlying factors that contribute to growth, albeit to a significant extent indirectly by enhancing the investment in EHC.

The second is our specification of a corresponding econometric model that allows a direct implementation of the testable, and rejectable, propositions of our model against panel data generated by annual GEM adult population surveys of entrepreneurs and entrepreneurial activity around the world. The panel data set we are able to employ is limited by data exigencies that restrict the sample size in terms of the number of countries and mainly the years of data it covers. We also rely on empirical proxies of our main theoretical constructs. Nevertheless, the basic results we generate by using two alternative samples, alternative estimation procedures, and robustness and corroborating tests of our null hypothesis against alternative hypotheses, provide strong support for our basic propositions.

In the main, we offer three related propositions imbedded in the specification of a two-step recursive model. The first step, represented by equation (14), specifies the equilibrium level of investment in EHC (*INVEC*), as a function of predetermined institutional protections, guaranteeing a competitive rate of return to *INVEC* in a free market system (for both ideas and goods production) governed by the rule of law (*I*), and the predetermined level of general human capital attained by entrepreneurs, which raise the cost effectiveness of *INVEC*. The role of these factors, however, is also estimated conditionally on measures of the economy's development level, to account for the fact that most states in our sample are in various phases of transition toward our theoretical steady state of balanced growth. The second step specifies the dynamic growth path of the representative enterprise in the economy as a function of the actual, or expected level of *INVEC*, which is similarly conditioned on measures of the economy's level of development, capital deepening, and openness to external trade, as specified by equation (15). The results of our empirical investigation lend strong support to these predictions.

We estimate the recursive model via OLS methods on the assumption that investment in entrepreneurial human capital by the representative enterprise takes place ahead of its realized impact on the *INVEC,* as predicted by the representative entrepreneur. We also allow, however, for a potential feedback effect that occurs as a result of changes in exogenous factors not controlled by the entrepreneur, which could, in turn, affect the contemporaneous demand for investment by the entrepreneur. The empirical evidence we gather by implementing 2SLS and IV methods to purge potential simultaneity biases offers inconclusive evidence of simultaneity since in most applications, the IVs are weak or the or the Hausman tests fail to reject the exogeneity of INVEC.

Notable, however, the empirical estimates of the estimated coefficients of equation (15) are remarkably similar in magnitude across both columns 3 and 4 in Table 4, where *INVEC*'s estimated effect is based on strong IVs, and in columns 5 and 6 of Table 3, where *INVEC*'s effect is estimated via OLS by using its predicted value (based on the reduced form of the recursive model) to estimate equation (15). These estimates suggest that a 10 percentage-point increase in investment in entrepreneurial human capital could raise the per-capita income growth rate by 0.5 to 1.1 percentage points.

Our estimates of equation (15) remain stable and of similar order of magnitude even when we use total factor productivity, rather than real per-capital income (*GPPPC),* as the dependent variable in that equation. Moreover, our basic results concerning the independent role of *INVEC* in economic growth are corroborated when we expand equation (15) to include competing specifications that allow our institutional index and general human factors influencing *INVEC* to become a dominant driver of growth, instead of *INVEC* (illustrated in Table 5), or when we pit investment in entrepreneurial human capital to be the engine of growth against the alternative hypothesis that general human capital, as captured by flow or stock measures of higher education, is the dominating driver of growth (illustrated in Table 6).

Both Tables 5 and 6 support the hypothesis that investment in entrepreneurial human capital, approximated by *INVEC* exert *independent* influence on the economy's long-term dynamic growth and are not supportive of the hypothesis that the underlying measures of institutional factors or general measures of higher education are the exclusive or dominating engine of growth. These results should not be interpreted, however, as rejecting the hypothesis that general human capital or institutional factors may be the true underlying engine of growth. In this analysis we have not fully specified a model of institutions or higher education as drivers of basic science and innovative ideas, which in turn exert an independent, if not dominating, influence on long-term growth. The results of our corroborative regression analyses do suggest, however, that institutional factors, and especially the higher education level of entrepreneurs or the general population, do operate indirectly as drivers of endogenous growth, in part as enabling factors which enhance the role entrepreneurial human capital formation as an independent channel driving long-term productivity and per-capita income growth.

Endnotes

[1] See, e.g., Audretsch and Keilbach, 2004; Klapper et al., 2010 Blanchflower, 2000; Salgado-Banda, 2007; Braunerhjelm et al. 2010.

[2] See Jens Iversen et al. (2008) for a detailed discussion of definitions and measurements of entrepreneurship.

[3] Standout examples of innovative entrepreneurs include Andrew Carnegie, John D. Rockefeller, Henry Ford, Thomas Edison, Estee Lauder, Sam Walton, Bill Gates, Steve Jobs, Oprah Winfrey, Mark Zuckerberg.

[4] The GEM 'Adult Population Survey' is a unique instrument used to measure the level and nature of entrepreneurial activity around the world. It is administered by GEM National Teams to a representative national sample of at least 2000 respondents.

[5] An alternative institution measure is the index of democracy created by the Economist Intelligence Unit. This index is based on 60 indicators grouped in five different categories: electoral process and pluralism, civil liberties, functioning of government, political participation and political culture. However, the use of this index would reduce our sample by about 50% because it was first available in 2006.

[6] Equation (14) represents our baseline regression model as estimated in our smaller sample, where we have information about our preferred measure of entrepreneurs' higher education attainment. In our expanded sample we replace $ENTGRAD_0$ by our measure of the college-educated share of the population, POPCOLL, as measured in section 4.1.

[7] Penn World Tables group countries into 7 regions: Advanced Economies, East Asia and the Pacific, Europe and Central Asia, Latin America and the Caribbean, Middle East and North Africa, South Asia, and Sub-Saharan Africa.

[8] GDP per capita in year t can linked to its value at an initial year via (a) $GDPPC_t = (GDPPC_0) \exp[g(Z_t)t] \exp(u_t)$, where the growth rate g(Z) is a function of a vector of regressors, Z. By proposition 3 (equations 12 and 13), our growth rate function can be specified as $g(Z_t) = \beta_1 + \beta_2$ INVEC $+ \beta_3 X_t$. Taking the log of (a), we obtain equation (15).

[9] This pattern is confirmed when we rerun model 4 using the smaller sample. The resulting estimates are larger in the smaller sample: 0.00906 for $INSTALL_0$, 5.539 for $POPCOLL_0$, and -0.0845 for $INSTALL_0$*$POPCOLL_0$.

[10] Repeating the column 8 regression using the smaller sample, T is again found to have an insignificant effect on *INVEC.* The effects of the other key determinants of INVEC are found to be higher than those corresponding variables in column 8: 0.00910 for $INSTALL_0$, 5.602 for $POPCOLL_0$, and -0.0852 for $INSTALL_0$*$POPCOLL_0$.

[11] Since this method produces estimates of a "just-identified" system, we cannot apply any over-identification exclusion tests using this method.

[12] The Kleibergen-Paap F-statistic suggests that the constructed IVs are strong for the small sample model but not for the large sample model.

[13] To some degree, this may be the result of erroneously using stock, not flow, measures of human capital to estimate its effect on growth, or of regression specifications involving alternative levels of human capital that drive growth, or of failure to test for reverse causality going from growth to human capital measures. See Bils and Klenow (2000), Pritchett (2001), Cohan and Soto (2007)), and Ehrlich (2007).

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Table 1. Summary Statistics of Key Variables

Variables	Mean	Standard deviation	Number of observations
Panel A: small sample			
INVEC	0.425	0.140	116
$INSTALL_0$	69.509	7.543	116
$ENTGRAD_0$	0.0664	0.0597	116
$LRGDPPC_0$	9.866	0.728	116
$POPEDYRS_0$	9.374	1.933	116
$L(K/L)_0$	11.67	0.729	116
LRGDPPC	9.962	0.728	116
OPEN	0.630	0.948	116
GOV	0.150	0.049	116
$TER\text{-}ENRL_0$	53.732	16.264	116
$TER\text{-}YRS_0$	0.605	0.359	116
LTFP	-0.2230	0.310	116
$LTFP_0$	-0.2234	0.362	116
Panel B: large sample			
INVEC	0.383	0.149	309
$INSTALL_0$	66.555	8.952	309
$POPCOLL_0$	0.127	0.0669	309
$LRGDPPC_0$	9.605	0.879	309
$POPEDYRS_0$	8.895	1.902	309
$L(K/L)_0$	11.504	0.844	309
LRGDPPC	9.769	0.803	309
OPEN	0.792	0.619	309
GOV	0.169	0.0609	309
$TER\text{-}ENRL_0$	50.250	19.601	268
$TER\text{-}YRS_0$	0.464	0.294	309
LTFP	-0.327	0.336	304
$LTFP_0$	-0.346	0.405	304

List of countries:

(1) **Smaller sample**: Argentina, Australia, Canada, Chile, Denmark, France, India, Ireland, Israel, Japan, Mexico, S. Africa, Switzerland, Taiwan, Thailand, UK, US.2) **Larger sample**: Argentina, Australia, Austria, Belgium, Bolivia, Brazil, Canada, Chile, China, Columbia, Croatia, Denmark, Ecuador, Egypt, Finland, France, German, Greece, Hong Kong, Hungary, Iceland, India, Indonesia, Iran, Ireland, Israel, Italy, Jamaica, Japan, Jordan, Kazakhstan, South Korea, Latvia, Malaysia, Mexico, Netherland, New Zealand, Norway, Panama, Peru, Philippine, Poland, Portugal, Romania, Russia, S. Africa, Saudi Arabia, Serbia, Singapore, Slovenia, Spain, Sweden, Switzerland, Syria, Taiwan, Thailand, Tunisia, Turkey, Uganda, UK, Uruguay, US, Venezuela.

Table 2. *INVEC* regressions: OLS estimates of the first step of the recursive model

VARIABLES	(1) Small sample	(2) Small sample	(3) Large sample	(4) Large sample	(5) Small sample	(6) Small sample	(7) Large sample	(8) Large sample
$INSTALL_0$	0.00855**	0.0110***			0.00840**	0.0109***		
	(0.00372)	(0.00346)			(0.00364)	(0.00343)		
$ENTGRAD_0$	9.117***	13.63***			9.021***	13.59***		
	(2.871)	(2.845)			(2.752)	(2.751)		
$INSTALL_0$*$ENTGRAD_0$	-0.130***	-0.190***			-0.129***	-0.189***		
	(0.0413)	(0.0409)			(0.0396)	(0.0395)		
INSTALL (first available)			0.00704***	0.00777***			0.00722***	0.00791***
			(0.00155)	(0.00277)			(0.00152)	(0.00271)
POPCOLL (first available)			2.731***	3.076***			2.925***	3.243***
			(0.613)	(0.965)			(0.600)	(0.939)
INSTALL*POPCOLL			-0.0414***	-0.0466***			-0.0443***	-0.0489***
			(0.00853)	(0.0146)			(0.00832)	(0.0142)
$LRGDPPC_0$		-0.163***		0.00216		-0.161***		0.00238
		(0.0394)		(0.0252)		(0.0354)		(0.0250)
$POPEDYRS_0$		0.0314***		-0.00238		0.0307***		-0.00264
		(0.00760)		(0.00835)		(0.00720)		(0.00831)
T					0.00178	0.00290	-0.00244	-0.00168
					(0.00457)	(0.00408)	(0.00372)	(0.00381)
Constant	-0.0223	1.002**	-0.0180	-0.0601	-0.00635	0.985***	0.00214	-0.0425
	(0.248)	(0.382)	(0.0939)	(0.259)	(0.243)	(0.344)	(0.0969)	(0.255)
Year dummies	Yes	Yes	Yes	Yes	No	No	No	No
Region dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
R-squared	0.468	0.582	0.201	0.183	0.460	0.575	0.186	0.170
Observations	116	116	317	309	116	116	317	309

Notes: Heteroscedasticity and autocorrelation consistent standard errors in parentheses *** $p<0.01$, ** $p<0.05$, * $p<0.1$

Table 3. *LRGDPPC* regressions: OLS estimates with observed and predicted values of *INVEC* used as regressors

VARIABLES	(1) Small sample observed INVEC	(2) Large sample observed INVEC	(3) Small sample predicted INVEC using recursive specification	(4) Large sample predicted INVEC using recursive specification	(5) Small sample predicted INVEC using reduced form specification	(6) Large sample predicted INVEC using reduced form specification
INVEC	-0.240*	-0.150	-0.645***	0.0162	-0.520***	-0.192
	(0.128)	(0.101)	(0.151)	(0.561)	(0.154)	(0.652)
T*INVEC	0.0614***	0.0504***	0.116***	0.0740	0.112***	0.114***
	(0.0178)	(0.0159)	(0.0351)	(0.0575)	(0.0368)	(0.0410)
T	-0.00792	-0.0188	-0.0311*	-0.00264	-0.0294*	-0.0188
	(0.00999)	(0.0159)	(0.0156)	(0.0209)	(0.0162)	(0.0159)
$LRGDPPC_0$	0.917***	0.883***	0.883***	0.855***	0.906***	0.883***
	(0.0356)	(0.0671)	(0.0483)	(0.0663)	(0.0380)	(0.0671)
$POPEDYRS_0$	0.0259***	0.0101	0.0261***	0.00682	0.0217***	0.0101
	(0.00569)	(0.0115)	(0.00704)	(0.00967)	(0.00611)	(0.0115)
$L(K/L)_0$	-0.0975***	-0.0276	-0.0833***	-0.00432	-0.0866***	-0.0276
	(0.0205)	(0.0636)	(0.0281)	(0.0620)	(0.0227)	(0.0636)
OPEN	0.0866***	0.00595	0.107***	-0.00101	0.0923***	0.00595
	(0.0175)	(0.0214)	(0.0234)	(0.0240)	(0.0213)	(0.0214)
GOV	-0.714***	-0.379	-0.646***	-0.823***	-0.680***	-0.371
	(0.129)	(0.712)	(0.161)	(0.217)	(0.137)	(0.712)
Constant	0.996***	0.958***	2.059***	1.337***	1.881***	1.325**
	(0.206)	(0.210)	(0.215)	(0.395)	(0.197)	(0.525)
Region dummies	Yes	Yes	Yes	Yes	Yes	Yes
Observations	116	309	116	309	116	309
R-squared	0.994	0.980	0.995	0.979	0.995	0.980

Notes: Heteroscedasticity and autocorrelation consistent standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Table 4. *LRGDPPC* regressions: IV estimates using alternative instrumental variables

VARIABLES	(1) Small sample 2SLS	(2) Large sample 2SLS	(3) Small sample with predicted INVEC* and T*INVEC* as IVs	(4) Large sample with predicted INVEC* and T*INVEC* as IVs
INVEC	-0.199	-0.680*	-0.331**	-0.210
	(0.199)	(0.387)	(0.159)	(0.430)
T*INVEC	0.0586	0.106	0.0935***	0.114***
	(0.0470)	(0.0681)	(0.0221)	(0.0407)
T	-0.00681	-0.0162	-0.0217**	-0.0192
	(0.0209)	(0.0263)	(0.0103)	(0.0159)
$LRGDPPC_0$	0.921***	0.833***	0.933***	0.871***
	(0.0563)	(0.0467)	(0.0521)	(0.0519)
$POPEDYRS_0$	0.0194**	0.00896	0.0167**	0.0119
	(0.00834)	(0.00746)	(0.00780)	(0.00874)
$L(K/L)_0$	-0.0969***	0.0164	-0.103***	-0.0189
	(0.0324)	(0.0438)	(0.0298)	(0.0462)
OPEN	0.0844***	0.00610	0.0731***	0.00573
	(0.0302)	(0.0161)	(0.0267)	(0.0169)
GOV	-0.715***	-0.831**	-0.716***	-0.375
	(0.160)	(0.330)	(0.166)	(0.517)
Constant	1.741***	1.615***	1.785***	1.351***
	(0.307)	(0.303)	(0.322)	(0.365)
Region dummies	Yes	Yes	Yes	Yes
Sauderson-Windmeiler	5.00	1.68	17.65	10.03
F-statistic[a]	3.46	1.83	57.95	30.88
Robust Kleibergen-Paap F-statistic[b]	2.502	1.840	7.274	3.856
	(20.680)	(20.680)	(7.030)	(7.030)
Endogeneity test Chi-squared statistic (p-value)	2.703	4.096	7.296	3.683
	(0.2588)	(0.1290)	(0.0260)	(0.1586)
Observations	116	309	116	309
R-squared	0.994	0.978	0.993	0.977

Notes: Heteroskedasticity and autocorrelation consistent standard errors are in parentheses. *** p<0.01, ** p<0.05, * p<0.1. Instrumental variables used include $INSTALL_0$, $ENTGRAD_0$, $INSTALL_0$*$ENTGRAD_0$, T*$INSTALL_0$, T*$ENTGRAD_0$, and T*$INSTALL_0$*$ENTGRAD_0$ in column 1, and $INSTALL_0$, $POPCOLL_0$, $INSTALL_0$*$POPCOLL_0$, T*$INSTALL_0$, T*$POPCOLL_0$, and T*$INSTALL_0$*$POPCOLL_0$ in column 2. In columns 3 and 4 the instrumental variables are INVEC* and T*INVEC*, where INVEC* is the predicted value of INVEC via the regression models of columns 6 and 8 of Table 2, based on the small and large samples, respectively. [a] Sauderson-Windmeiler is a multivariate F test of the excluded IVs in the reduced form regressions for INVEC and T*INVEC. [b] Robust Kleibergen-Paap is a F test of weak IV, the number in parentheses is the critical value for weak IV bias up to 10% of the IV estimates, F-statistics smaller than the critical value suggest weak IVs.

Table 3A. *LTFP* regressions: OLS estimates using observed and predicted value of *INVEC*

VARIABLES	(1) Small sample observed INVEC	(2) Large sample observed INVEC	(3) Small sample predicted INVEC using recursive specification	(4) Large sample predicted INVEC using recursive specification	(5) Small sample predicted INVEC using reduced form specification	(6) Large sample predicted INVEC using reduced form specification
INVEC	-0.201*	-0.189	-1.079***	-0.311	-0.675***	-0.484
	(0.102)	(0.133)	(0.254)	(0.572)	(0.187)	(0.449)
T*INVEC	0.0378**	0.0448***	0.104**	0.0668	0.0824**	0.0782***
	(0.0169)	(0.0144)	(0.0388)	(0.0454)	(0.0363)	(0.0291)
T	-0.0216**	-0.0202***	-0.0488**	-0.0282	-0.0402**	-0.0331***
	(0.00967)	(0.00699)	(0.0178)	(0.0175)	(0.0165)	(0.0117)
$LTFP_0$	0.840***	0.703***	0.694***	0.707***	0.802***	0.703***
	(0.0393)	(0.0852)	(0.0419)	(0.0830)	(0.0336)	(0.0845)
$POPEDYRS_0$	0.00428	0.00930	0.0263***	0.00751	0.0113	0.00819
	(0.00988)	(0.00959)	(0.00871)	(0.0104)	(0.00926)	(0.0124)
$L(K/L)_0$	0.0163	0.00193	-0.0261	0.00153	-0.00449	0.000397
	(0.0204)	(0.0412)	(0.0167)	(0.0401)	(0.0163)	(0.0426)
OPEN	0.0743**	0.00998	0.137***	0.00849	0.0937***	0.0109
	(0.0288)	(0.0191)	(0.0256)	(0.0231)	(0.0269)	(0.0193)
GOV	-0.727***	-0.605**	-0.407***	-0.678***	-0.697***	-0.694
	(0.156)	(0.263)	(0.114)	(0.243)	(0.152)	(0.529)
Constant	-0.0882	-0.0590	0.467*	0.0144	0.269	0.102
	(0.245)	(0.511)	(0.233)	(0.601)	(0.226)	(0.692)
Region dummies	Yes	Yes	Yes	Yes	Yes	Yes
R-squared	0.968	0.901	0.975	0.898	0.973	0.900
Observations	116	304	116	304	116	304

Notes: Heteroscedasticity and autocorrelation consistent standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Table 4A. *LTFP* regressions: IV estimates using alternative instrumental variables

VARIABLES	(3) Small sample 2sls	(4) Large sample 2sls	(1) Small sample using predicted INVEC* and T*INVEC* as IVs	(2) Large sample using predicted INVEC* and T*INVEC* as IVs
INVEC	-0.376	-0.640*	-0.606***	-0.441
	(0.235)	(0.358)	(0.171)	(0.284)
T*INVEC	0.0152	0.0990*	0.0701***	0.0723**
	(0.0463)	(0.0559)	(0.0248)	(0.0286)
T	-0.0113	-0.0416*	-0.0348***	-0.0311***
	(0.0203)	(0.0217)	(0.0107)	(0.0119)
$LTPF_0$	0.797***	0.695***	0.806***	0.698***
	(0.0498)	(0.0532)	(0.0402)	(0.0525)
$POPEDYRS_0$	0.0129	0.00845	0.00987	0.00862
	(0.0105)	(0.00782)	(0.00913)	(0.00736)
$L(K/L)_0$	-0.0108	0.000649	-0.0124	0.00122
	(0.0297)	(0.0274)	(0.0285)	(0.0272)
OPEN	0.102***	0.0109	0.0892***	0.0104
	(0.0369)	(0.0129)	(0.0311)	(0.0129)
GOV	-0.723***	-0.706**	-0.715***	-0.677**
	(0.155)	(0.349)	(0.145)	(0.324)
Constant	0.195	0.172	0.345	0.0755
	(0.345)	(0.446)	(0.302)	(0.432)
Region dummies	Yes	Yes	Yes	Yes
Sauderson-Windmeiler F-statistic[a]	5.40	1.88	28.41	18.14
	3.44	1.98	63.96	38.43
Robust Kleibergen-Paap F-statistic[b]	2.72	2.85	15.70	6.66
	(9.480)	(9.480)	(7.030)	(7.030)
Endogeneity test Chi-squared statistic (p-value)	5.310	2.881	11.044	1.828
	(0.0703)	(0.237)	(0.004)	(0.401)
R-squared	0.959	0.894	0.959	0.898
Observations	116	304	116	304

Notes: Heteroskedasticity and autocorrelation consistent standard errors are in parentheses. *** p<0.01, ** p<0.05, * p<0.1. Instrumental variables used include $INSTALL_0$, $ENTGRAD_0$, $INSTALL_0$*$ENTGRAD_0$, T*$INSTALL_0$, T*$ENTGRAD_0$, and T*$INSTALL_0$*$ENTGRAD_0$ in column 1, and $INSTALL_0$, $POPCOLL_0$, $INSTALL_0$*$POPCOLL_0$, T*$INSTALL_0$, T*$POPCOLL_0$, and T*$INSTALL_0$*$POPCOLL_0$ in column 2. In columns 3 and 4 the instrumental variables are INVEC* and T*INVEC*, where INVEC* is the predicted value of INVEC via the regression models of columns 6 and 8 of Table 2, based on the small and large samples, respectively.

[a] Sauderson-Windmeiler is a multivariate F test of the excluded IVs in the reduced form regressions for INVEC and T*INVEC. [b] Robust Kleibergen-Paap is a F test of weak IV, the number in parentheses is the critical value for weak IV bias up to 10% of the IV estimates, F-statistics smaller than the critical value suggest weak IVs.

Table 5. *LRGDPPC* regressions: diagnostic tests concerning the independent roles of I and h

VARIABLES	(1) Small sample	(2) Small sample observed INVEC	(3) Small sample predicted INVEC using reduced form specification	(4) Large sample	(5) Large sample observed INVEC	(6) Large sample predicted INVEC using reduced form specification
INVEC		-0.174	-0.320		-0.0823	0.0512
		(0.141)	(0.183)		(0.0965)	(0.667)
T*INVEC		0.0476**	0.0891*		0.0438***	0.104**
		(0.0200)	(0.0426)		(0.0162)	(0.0411)
$INSTALL_0$	0.00356	0.00344	0.00350			
	(0.00344)	(0.00376)	(0.00389)			
$T*INSTALL_0$	-0.000360	-0.000345	-0.000269			
	(0.000684)	(0.000746)	(0.000778)			
$ENTGRAD_0$	0.761	0.610	0.471			
	(0.464)	(0.366)	(0.334)			
$T*ENTGRAD_0$	-0.176*	-0.144*	-0.121*			
	(0.0931)	(0.0729)	(0.0682)			
INSTALL				0.00376	0.00475	0.00424
(first available yr)				(0.00315)	(0.00309)	(0.00317)
T*INSTALL				-0.00110**	-0.00135***	-0.00140***
				(0.000510)	(0.000471)	(0.000429)
POPCOLL				0.953***	0.770**	0.635**
(first available yr)				(0.344)	(0.332)	(0.292)
T*POPCOLL				-0.0577	-0.0359	-0.0254
				(0.0650)	(0.0599)	(0.0562)
T	0.0550	0.0314	0.00678	0.106***	0.103***	0.0816***
	(0.0477)	(0.0604)	(0.0699)	(0.0296)	(0.0281)	(0.0271)
$LRGDPPC_0$	0.883***	0.901***	0.902***	0.860***	0.874***	0.924***
	(0.0226)	(0.0323)	(0.0304)	(0.0688)	(0.0709)	(0.0814)
$POPEDYRS_0$	0.0271***	0.0231***	0.0224***	-0.000596	0.00250	0.00693
	(0.00485)	(0.00555)	(0.00544)	(0.0104)	(0.0101)	(0.0139)
$L(K/L)_0$	-0.0854***	-0.0939***	-0.0845***	-0.0123	-0.0241	-0.0649
	(0.0180)	(0.0179)	(0.0148)	(0.0585)	(0.0577)	(0.0703)
OPEN	0.114***	0.0973***	0.0952***	0.0139	0.0155	0.0193
	(0.0147)	(0.0174)	(0.0164)	(0.0235)	(0.0232)	(0.0217)
GOV	-0.417*	-0.440**	-0.372*	-0.890***	-0.721***	-0.295
	(0.209)	(0.188)	(0.187)	(0.207)	(0.229)	(0.634)
Constant	1.479***	1.545***	1.491***	1.151***	1.078***	0.938*
	(0.256)	(0.376)	(0.363)	(0.392)	(0.388)	(0.542)
Region dummies	Yes	Yes	Yes	Yes	Yes	Yes
R-squared	0.994	0.995	0.995	0.982	0.983	0.983
Observations	116	116	116	309	309	309

Note: Heteroscedasticity and autocorrelation consistent standard errors in parentheses. *** p<0.01, ** p<0.05, *p<0.1

Table 6. *LRGDPPC* regressions: entrepreneurial capital investment vs general human capital flow or stock measures as engine of growth

VARIABLES	(1) Largest possible sample observed INVEC	(2) Largest possible sample observed INVEC	(3) Small sample predicted INVEC using reduced form specification	(4) Small sample predicted INVEC using reduced form specification	(5) Large sample predicted INVEC using reduced form specification	(6) Large sample predicted INVEC using reduced form specification
INVEC	-0.0546	-0.0739	-0.437	-0.546*	-0.0987	-0.129
	(0.109)	(0.0848)	(0.250)	(0.263)	(0.691)	(0.676)
T*INVEC	0.0503***	0.0435***	0.0986	0.100*	0.113**	0.119***
	(0.0170)	(0.0149)	(0.0635)	(0.0493)	(0.0464)	(0.0403)
ENRL-TER$_0$	0.00231**		0.00173		0.00258*	
	(0.00103)		(0.00247)		(0.00138)	
T* ENRL-TER$_0$	-0.000327**		-0.000351		-0.000433**	
	(0.000153)		(0.000510)		(0.000183)	
YRS-TER$_0$		0.108		0.184		0.144
		(0.0969)		(0.158)		(0.122)
T* YRS-TER$_0$		-0.0237***		-0.0151		-0.0236**
		(0.00887)		(0.0177)		(0.0113)
T	0.0249**	0.0212**	-0.00488	-0.0152	0.00522	-0.00628
	(0.00987)	(0.00881)	(0.0500)	(0.0310)	(0.0216)	(0.0176)
LRGDPPC$_0$	0.846***	0.841***	0.917***	0.818***	0.901***	0.898***
	(0.0688)	(0.0626)	(0.0513)	(0.126)	(0.0788)	(0.0735)
POPEDYRS$_0$	0.0188*	0.0180	0.0241**	0.00522	0.00895	0.00698
	(0.00956)	(0.0151)	(0.00839)	(0.0222)	(0.0131)	(0.0201)
L(K/L)$_0$	0.000676	0.00970	-0.0879***	-0.0530	-0.0430	-0.0403
	(0.0560)	(0.0560)	(0.0244)	(0.0466)	(0.0705)	(0.0682)
OPEN	-0.00982	0.0103	0.0952***	0.141*	-0.0192	-0.0162
	(0.0235)	(0.0193)	(0.0265)	(0.0665)	(0.0243)	(0.0254)
GOV	-0.551**	-0.620***	-0.656***	-0.643***	-0.236	-0.225
	(0.256)	(0.223)	(0.170)	(0.137)	(0.774)	(0.767)
Constant	1.205***	1.200***	1.779***	2.551**	1.125*	1.193**
	(0.327)	(0.255)	(0.324)	(0.898)	(0.610)	(0.541)
Region dummies	Yes	Yes	Yes	Yes	Yes	Yes
R-squared	0.978	0.980	0.994	0.994	0.979	0.979
Observations	303	352	101	101	268	268

Notes: Heteroscedasticity and autocorrelation consistent standard errors in parentheses. *** p<0.01, **p<0.05, * p<0.1