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HUMAN CAPITAL ENDOWMENTS AND THE PROPENSITY OF ENTREPRENEURS TO PATENT

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ABSTRACT

In this paper we show that the patenting behavior of creative entrepreneurs is correlated with the patenting behavior of their fathers, which we refer to as a source of the entrepreneurs' human capital endowments. Our argument for this relationship follows from established theories of developmental creativity, and our empirical analysis is based on survey data collected from MIT's Technology Review winners.

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1 Introduction

The propensity to patent by firms and entrepreneurs is related to the external and internal environment of each. The environment surrounding firms consists externally of their market structure and internally of their investments in research and development (R&D), among other things (Cohen 2010). That surrounding entrepreneurs also consists externally of their market environment and internally of both their financial ability (own or that of alternative investors) to move their technology to a market innovation and their incentive structure (Siegel et al. 2003).

Surprisingly, this literature has ignored human capital endowments when comparing the propensity to patent across entrepreneurs.[1] Link and Ruhm (2011) focused on investments in human capital and showed that prior business education/experience is a correlate with patenting. This paper extends the study of patenting by focusing on the developmentally-acquired creativity of the entrepreneur.

In Section II we posit a model of human capital endowments, obtained through observing parental behavior, and one's propensity to patent; we describe our database; and we present our empirical findings. Concluding remarks are in Section III.

2 The Propensity to Patent

2.1 An Empirical Model

Creativity is "the interaction among aptitude, process, and environment by which an individual or group produces a perceptible product that is both novel and useful." (Plucker et al. 2004, p. 90). Kaufman and Sternberg (2007) discuss creativity in several dimensions, often referred to as "4-Ps." The "Ps" are the creative person, product, process, and place (i.e., environment). Thus,

[1] Nicolaou et al. (2008) argued that genetic factors be considered for why individuals engage in entrepreneurial activity. Relatedly, Bates (1985) showed a positive relationship between human capital endowments and minority enterprise profitability.

a creative person can produce, through a creative process, a creative product; and it follows that the creative person and his/her process can be influenced by place.

Creativity, as reflected through innovativeness, is also a characteristic of an entrepreneur (Hébert and Link 2009); and patenting is a purposeful activity motivated to protect intellectual property (Sichelman and Graham 2010). Generally, a requirement for a patent is that the invention is novel, useful, and non-obvious (USPTO 2011).

Our framework stems from developmental theories of creativity. Goertzel and Goertzel (1976), Helson (1999), and others argued that developmental experiences of individuals, including parental guidance and family structure, are correlated with the demonstrated creativeness of individuals. The roots of the background of individuals establish the trajectory for their creative development (Kozbelt et al. 2010).[2]

Based on this argument, we hypothesize that the propensity of a creative individual (*i*) to patent is related to the same behavior of his/her parents:

(1) $\quad Patent_i = \mathrm{F}(\mathbf{X}_i + u_i > 0)$

where *Patent* measures the propensity of an individual to patent, **X** a vector of parental patenting activity and other characteristics, and $u_i \sim \mathrm{N}(0,1)$.

We estimated equation (1) using a rich and previously unexamined database of international inventors, as acknowledged by MIT's *Technology Review*.

2.2 *Technology Review* Database

To commemorate the 100th year of publication of MIT's innovation magazine, *Technology Review* (*TR*), 100 international inventors (under age 35 at nomination) from universities, businesses, and government laboratories, who have the potential to make major technology contributions in the decades ahead, were identified in the November/December 1999 issue of the

[2] Self-employed entrepreneurs often have fathers who were self-employed (Shane 2003).

Review (Benditt 1999). *TR*100 inventors received this distinction in 2002, 2003, and 2004. In 2005, and thereafter, the *TR*100 became the *TR*35.[3]

All *TR* winners, arguably among the most inventive young individuals from 1999 through 2009 (thus, not representative of all creative entrepreneurs) are the population for our survey-based study. We obtained e-mail addresses and were able to contact 341 of the 575 winners. Sixty-three, or 18.5 percent, of those returned surveys.[4] See Table 1.

The specification of equation (1) is parsimonious owing to limited survey information and to the relatively homogenous nature of *TR* winners. For example, 83 percent holds a terminal degree (i.e., PhD, MD, or JD) Nominees must be under 35; the age range in Table 3 is 26 to 35.

2.3 Empirical Findings

The variables used to estimate equation (1) are defined and descriptive statistics are in Table 2.

We estimated equation (1) using a two-part model. Regarding the probit results in column (1) of Table 3 for the full survey sample of n=63, creative entrepreneurs with fathers who patented are nearly 26 percentage points more likely to patent themselves compared to a similarly creative entrepreneur whose father did not patent, *ceteris paribus*. Also, those of Asian descent and those with a graduate degree in science or engineering are also relatively more likely to patent than other creative entrepreneurs. Finally, males are more likely to patent than females but the difference does not reach statistical significance (p-value=0.12).[5]

The second part of our estimation involves identifying correlates with the natural log of the number of patents received conditional on patenting. As seen in column (2) for the sample of n=29 who patented, those with a patenting father patent more, *ceteris paribus*. There is also evidence that age is a factor in determining the number of patents received rather than the *per se*

[3] This change coincided with a new editor at *Technology Review*.
[4] This response rate is on par with others innovation studies. The response rate for the National Research Council's (NRC's) Congressional mandated study of NASA Small Business Innovation Research award recipient firms was 23%.
[5] Baer and Kaufman (2008) argued that there are no gender differences in the creativity of individuals, based on traditional tools for measuring creativity.

propensity to patent, but this finding may only represent the fact that receipt of a patent is time intensive. And, nationality is not significant among those who patent, but field of study is.

Finally, in column (3), we treated patenting as a count process. The negative binomial results confirm the positive predicted effect of one's father having patented. Males and Asians also have higher patent counts, but field of study is no longer relevant reflecting the previous evidence that scientists and engineers are more likely to patent but in smaller numbers among those who do so.

Equation (1) was also estimated as a probit model with control for survey response; that is, it was estimated as a maximum likelihood model with selection. The model for non-response was estimated as a function of the award year, *Year*, under the argument that the earlier in time the award the less likely the awardee would respond to the survey, and the probit results confirmed this. However, when estimated simultaneously with the probability of patenting model, the correlation between the error terms was not significant. Separately, we estimated the model underlying the results in column (1) of Table 3 with *Year* and a regressor. The estimated coefficient on *Year* was not significant thus supporting the conclusion that this variable could reasonably be excluded from the patenting probit model.

3 Concluding Observations

We caution against generalizing from our patent-specific findings that observed parental behavior is related to other dimensions of entrepreneurial creativity. Our sample of *TR* winners is unique, and our economic analysis is exploratory in structure and scope. Nevertheless, our findings might suggest that human capital endowments be considered in future studies of innovative behavior.

Table 1
Data Reduction Process

Year	**Winners**	**Number of Surveys**	**Responses**	**Response Rate**
1999	100	64	8	12.5%
2002	100	53	9	17.0%
2003	100	55	8	14.5%
2004	100	58	9	15.5%
2005	35	22	6	27.3%
2006	35	22	4	18.2%
2007	35	19	5	26.3%
2008	35	24	5	20.8%
2009	35	24	9	37.5%
	575	341	63	18.5%

Table 2
Definition and Descriptive Statistics for Variables Relevant to *TR* Entrepreneur (n=63)

Variable	Definition	Mean	Std. Dev.	Range
Dependent				
Patent	1 if ≥ 1 patent granted through 2009, 0 otherwise	0.4603	0.5024	0/1
NoPat	Number of patents granted through 2009	1.9048	4.1648	0-20
Independent				
DadPatent	1 if the father granted ≥ 1 patent through 2009, 0 otherwise	0.2381	0.4293	0/1
Female	1 if female, 0 if male	0.3810	0.4895	0/1
Age	Age when *TR* award announced	31.3492	2.4832	26-35[a]
Asian	1 if *TR* winner is Asian, 0 otherwise	0.2222	0.4191	0/1
Science[b]	1 if field of study in the basic sciences, 0 otherwise	0.3810	0.4895	0/1
Engineer	1 if field of study in engineering, 0 otherwise	0.3333	0.4752	0/1
Year	Year of award	2004.444	3.1201	1999-2009

Note:
None of the *TR* winner's mothers held a patent.
[a] Several *TR* winners turned 35 by the time of the award.
[b] Non-science and non-engineering fields of study include: art, business, history, medicine, and philosophy.

Table 3
Estimation of Equation (1)

Variable	**(1)** **Dep. Var.=*Patent*** **Estimation: Probit**	**(2)** **Dep. Var.=*lnNoPat*** **Estimation: OLS**	**(3)** **Dep. Var.=*NoPat*** **Estimation: Negative Binomial**
DadPatent	0.2555	0.7186	3.5061
	(0.1322)*	(0.3053)**	(1.7337)**
Female	-1.6901	-0.1190	-0.8841
	(0.1093)	(0.3013)	(0.5132)*
Age	0.0086	0.1085	0.2767
	(0.0212)	(0.0608)*	(0.1866)
Asian	0.4949	0.3920	3.1034
	(0.1022)***	(0.2875)	(1.1169)***
Science	0.3267	-0.8572	0.6965
	(0.1317)**	(0.4019)**	(1.123)
Engineer	0.2805	-1.2783	-0.3166
	(0.1453)*	(0.4234)***	(0.7830)*
constant	--	-2.0630	--
		(1.9546)	
n	63	29	63
LR/Wald χ^2	23.56	--	64.25
Pseudo R^2	0.2710	--	--
Log pseudo-likelihood	-31.69	--	-90.58
R^2	--	0.6193	--
F-Statistic	--	5.96	--

Note: Average marginal effects are displayed in columns (1) and (3), regression coefficients in column (2).
*significant at 0.10 level, **significant at 0.05 level, ***significant at 0.01 level.

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