How Risky Is College Investment?

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Motivation

50% of college entrants drop out.

Two interpretations:

1. Risk: College completion is uncertain
   Suggests a need for insurance arrangements
2. Heterogeneity: College completion is predictable
   Students differ in "ability," college preparation, financial resources
   Suggests a need for grants, loans, remedial coursework

Our questions:

1. How uncertain is college graduation from the perspective of students?
2. How valuable is insurance against college related financial risks?

Our Approach

Our goal:

- Develop and calibrate a model of college choice.
- Quantify the distribution of graduation probabilities among college freshmen.

The challenge: We do not observe

- student's information sets,
- abilities or college preparation

Our proposed solution:

- We model in detail how students progress through college.
- This allows us to use transcript data to discipline the model.

Transcript Data

We obtain college transcripts for 2,000 college freshmen around 1982

- NELS:88 and PETS

We focus on students' credit accumulation rates.

Transcripts reveal large and persistent heterogeneity in credit accumulation rates.

- Dropouts earn about 1/3 fewer credits per year compared with graduates.

One interpretation: students' inability to complete the requirements for a college degree may be an important reason for dropping out.

Structural Model

The main departure from the literature:

We model credit accumulation in college

Key model features:

- In college, students take courses with pass/fail outcomes.
- High ability students pass courses with higher probability
- Students learn about their abilities from course outcomes.
- Graduating from college requires a minimum number of earned credits.
- Students are endowed with heterogeneous financial resources and ability signals.

Main Findings

More than half of college entrants can predict college graduation with at least 80% accuracy.

- The main predictor of graduation is the ability signal.
- Financial heterogeneity is not important.

Policy implications:

- For the majority of students, insuring college related financial risks has little value.
  Related policies: income or graduation contingent loans
- For a large majority of students, providing additional information about their college preparation (ability) has little value
  Related policies: dual enrollment programs

Contribution Relative to the Literature

Structural models of college choice with dropout risk

- Keane and Wolpin (1997), Akyol and Athreya (2005), Chatterjee and Ionescu (2012), Johnson (2013)
- we model how students progress through college
- graduation requires credits, not just time in college

Structural models of progress through college

- Garriga and Keightley (2007), Stange (2012), Trachter (2014)
- we use transcript data (credit accumulation) to discipline the model

Transcript Data

Transcript Data

Postsecondary Transcript Study

Representative sample of HS sophomores in 1980

5,800 HS graduates

Data on:

- transcripts: credits earned, grades, ...
- college financing: parental transfers, loans, ...
- background: HS GPA, ...

Focus on number of credits earned at the end of each year in college

Credit Accumulation Over Time

Group	Year 1	Year 2	Year 3	Year 4
20th percentile	17	41	68	100
50th percentile	28	57	87	119
80th percentile	33	66	98	130
College dropouts	21	43	60	77
College graduates	31	60	90	119

Key points:

1. Large heterogeneity
2. Large gaps between graduates and dropouts

Credit Accumulation and GPA

Credits earned at the end of year 2

GPA quartile	Credit distribution 20th	50th	80th	Median credits CD	CG	Fraction graduating
1	21	38	57	32	57	10.7
2	36	50	62	46	57	24.9
3	37	55	64	44	58	50.8
4	50	61	68	45	62	73.6
All	41	57	66	44	60	52.5

Key points:

1. Large gaps across GPA quartiles $\rightarrow$ ability
2. Large heterogeneity within GPA quartiles $\rightarrow$ luck (?)

Credit Accumulation Over Time

	Year $1-2$	Year $2-3$	Year $3-4$
Correlations	0.48	0.42	0.39
Eigenvalues	0.51	0.47	0.41
N	1665	1378	1196

Key points:

1. Credits accumulation rates are persistent over time
2. Suggests a role for ability

▸ Simple model

The Model

Model Outline

At $t = 1$ all students graduate from high school.

They draw **endowments**:

- **financial**: assets, college costs, parental transfers
- "**ability**" (college preparation)

High school graduates can work or enter college

In college, students

- take courses (earn **credits**)
- choose consumption / saving, work / leisure
- decide whether to drop out or study another year

Students **graduate** if they earn 125 credits

Key Model Features

1. Students need to earn credits to graduate
   transcripts contain information about graduation prospects
2. Students infer their abilities from course outcomes
   Manski (1989)
3. Dropping out is a choice
   college has an option value
   dropping out limits financial risk

Endowments at High School Graduation

1. $n_1 = 0$ completed college credits
2. learning **ability** a
   not observed until the start of work
3. **type** $j \in \{1, ..., J\}$ which determines
   1. initial assets $\hat{k}_j$
   2. net price of attending college $\hat{q}_j$
   3. parental transfers $\hat{z}_j$
   4. ability signal $\hat{m}_j$
4. financial **shock** $\zeta_t \in \{1, ..., N_f\}$
   determines (q, z) and college earnings in each period

College Entry Decision

State vector:

1. $n = 0$ credits
2. type j
3. financial shock ζ_1
4. age 1

Enter college if the $V_C > V_W = \mathbb{E}_a \{V\}$.

To prevent perfect sorting: extreme value preference shocks

Work Phase

A standard permanent income problem:

$$V(k_\tau, n_\tau, a, s, \tau) = \max_{\{c_t\}} \sum_{t=\tau}^{T} \beta^{t-\tau} u(c_t) + U_s \tag{1}$$

subject to the budget constraint

$$\underbrace{\exp\left(\phi_s a + \mu n_\tau + y_s\right)}_{\text{lifetime earnings}} + R k_\tau = \sum_{t=\tau}^{T} c_t R^{\tau-t} \tag{2}$$

College Phase

A college student

- enters the period with state vector (k, n, ζ, j, t)
- attempts n_c credits
- earns each credit with probability $p(a)$
- updates beliefs about a.
  - Sufficient statistic for beliefs: n_{t+1}, j, t
- decides whether to study or work next period

College Decision Problem

$V_C(n_t, k_t, \zeta_t, j, t) =$
$\max u(c_t, 1 - v_t) + \beta \mathbb{E}_{n_{t+1}, iFin_{t+1}} V_{EC}(n_{t+1}, k_{t+1}, \zeta_{t+1}, j, t+1)$

subject to

- budget constraint

$$k_{t+1} + c_t + q(\zeta_t, j) = Rk_t + \hat{z}_j + w_{coll} v_t. \tag{3}$$

- borrowing constraint:

$$k_{t+1} \geq -k_{min}. \tag{4}$$

- financial shock determines feasible work hours:

$$v \in \Omega_\zeta \subset \{v_1, ..., v_{N_w}\} \tag{5}$$

Continuation Value

$$V_{EC}(n_t, k_t, \zeta_t, j, t) =$$
$$\mathbb{E}\max\{\underbrace{V_C(n_t, k_t, j, t) - \pi\eta_c}_{\text{study next period}}, \underbrace{V_W(k_t, n_t, \zeta_t, j, s(n_t), t) - \pi\eta_w}_{\text{work next period}}\}$$

Cases:

1. If $n \geq n_{grad}$: work as a CG.
2. If $t = T_c$ and $n < n_{grad}$: work as CD.
3. Otherwise: choose between working as CD or studying next period.

Model Recap

Individuals enter the model as HS graduates

endowed with

- financial resources
- ability signal
- financial and preference shocks

In each period, they decide whether to study or work

College students take courses

Course outcomes gradually reveal their abilities

Students drop out if they receive poor "grades" or run out of funds

Setting Model Parameters

Calibration Strategy

Simulate histories for 100,000 HS graduates.

Minimize the sum of squared deviations between model and data moments.

Key data moments: credit accumulation rates

- means, persistence,
- differences across GPA groups and between CG and CD
- direct mapping from data credits to model credits n

▸ Fixed model parameters

Calibrated Parameters

28 parameters are jointly calibrated

- endowment distributions
- financial and preference shocks
- lifetime earnings
- preferences
- credit accumulation rate $p(a)$

Important:

- ability signals m are very precise
- GPA is fairly noisy

▸ Endowments ▸ Calibrated parameters ▸ Endowment-correlations

Calibration Targets

1. Credit accumulation rates
   1. by GPA, year in college, graduation outcome
   2. persistence over time
2. College entry and graduation rates (by GPA)
3. Dropout rates (by GPA, t)
4. Lifetime earnings (by GPA, schooling)
5. Financial moments
   1. college costs, parental transfers
   2. earnings in college
   3. student debt

Model Fit

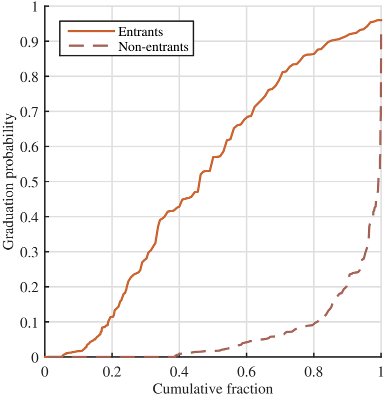
The model recovers challenging data moments:

1. Large dispersion in **credit accumulation** rates
   Also covariation with GPA and autocorrelation
2. 20% of low GPA students enter college, even though very few graduate
3. About half of students **drop out** of college
   Some drop out after spending 3 or more years in college
4. Few students are close to **borrowing** limits

Credits | Credit persistence | College outcomes | Dropouts | Debt

Results

Distribution of Graduation Probabilities



Among colleg entrants:

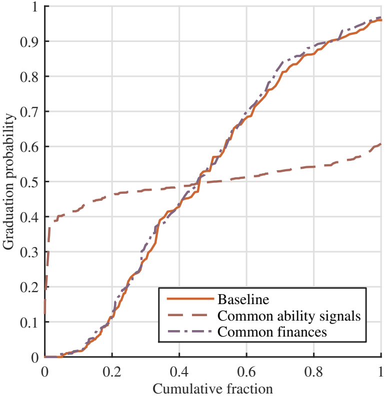
- 24% face graduation probabilities below 20%
- 30% face graduation probabilities above 80%.

Among non-entrants:

- 90% face graduation probabilities below 20%.

▸ Robustness

Why Is Graduation Predictable?



Counterfactuals:

1. Shut down financial heterogeneity:
   Minor changes in graduation probabilities
2. Shut down ability heterogeneity:
   Graduation probabilities around 0.5 for all entrants

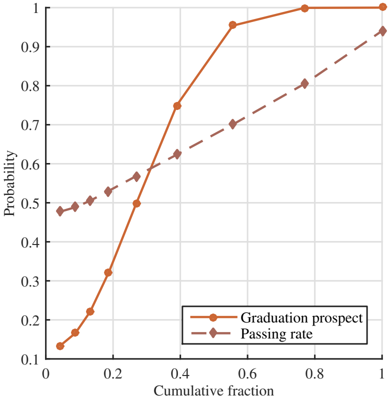
Conclusion: Ability drives most of the heterogeneity in graduation rates

Why Do Abilities Predict Graduation?

1. Graduation prospects differ greatly between high and low ability students.
   So that the model can generate dispersion in credit accumulation rates
2. Graduation probabilities are closely related to graduation prospects.
   Because the financial incentives for studying depend strongly on a
3. Students' ability signals are very precise.

Graduation prospect = probability of earning enough credits for graduation in T_c years.

Abilities and Graduation Prospects



Among college entrants:

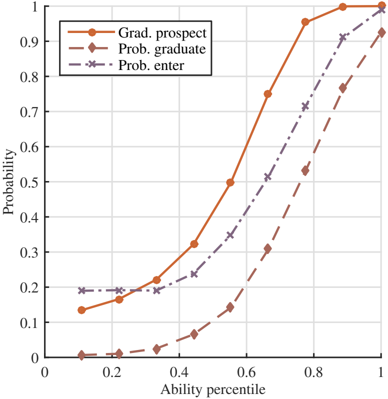
1. 61% face graduation prospects above 80%.
2. 9% face graduation prospects below 20%.

Intuition:

The Binomial credit distribution limits the role of luck.

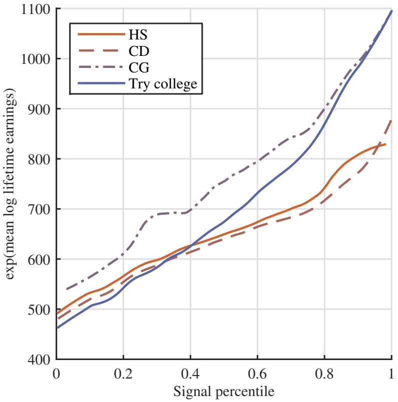
Large heterogeneity in $p(a)$ is needed to generate credit dispersion

Graduation Prospects and Outcomes



1. Graduation rates and entry rates are closely related to $g(p)$.
2. Many low ability students drop out
   even though they could have graduated

Financial Stakes



1. For dropouts:
   college has little effect on lifetime earnings
2. For low ability students:
   trying to graduate (staying in college for 6 years) does not raise lifetime earnings

Implications:

1. Low ability students are sensitive to shocks
2. High ability students are not

Precision of Ability Signals

Why does the model imply that ability signals are precise?

We calibrate the model fixing the $corr(a,m)$ at 0.44 (vs 0.92 in the baseline case)

	Data	Baseline	Noisy signal
Differences between high/low test score students:			
- credit accumulation rate (year 2)	0.28	0.27	0.10
- college dropout rate	0.63	0.63	0.32
- college entry rate	0.59	0.60	0.76
College entry rate, ability above/below median		0.58	0.28
Log lifetime earnings gap, CD vs HS	0.07	0.06	-0.02
Fraction with low / high graduation probabilities		24 / 30	2 / 3

Policy Experiments

Policy Experiments

Our main finding:

Graduation outcomes are highly predictable for the majority of students.

What does this imply for the potential gains due to policy interventions?

We study:

1. Insurance against financial risks (dropping out, delayed graduation)
2. Information about college preparation

Providing Insurance

Each college student receives the average consumption stream during the work phase.

This insures against:

- financial shocks in college
- graduation risk
- risk of slow graduation

No implementation costs

No change in student behavior (adverse selection or moral hazard)

Similar in spirit to income contingent loans

Providing Insurance

Insurance within	(a,j) groups		j groups	
Welfare gains	median	mean	median	mean
All	0.05	0.15	0.22	0.40
Entrants	0.27	0.27	0.68	0.65
High risk entrants	0.38	0.38	0.89	0.90

Median welfare gain: 0.68% of baseline consumption

Most of the gain is due to

- "insurance" against effect of unknown ability on earnings
- high risk entrance (with graduation rates between 20% and 80%)

Providing Information

The intervention:

- Costlessly provide each HS graduate with precise information about a.
- Students update decision rules

Similar in spirit to dual enrollment programs.

Mean welfare gain among college entrants: 0.21% of baseline consumption.

The median welfare gain is essentially 0.

Future Work

1. Study specific policies
   e.g. income contingent loans
   requires a model with more detail during the work phase
2. College quality
   how efficiently are students matched to college of different qualities?

Detail Slides

A Simple Model

What do transcript data imply for students' graduation chances?

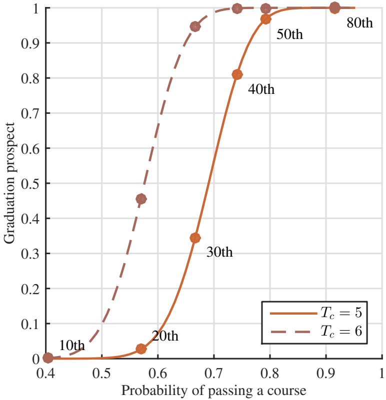
Consider a simple model:

- Students enter college with $n = 0$ earned courses.
- They attempt $n_c = 12$ courses per year, each yields 3 credits (this is the number of credits earned by students in the 90^{th} percentile)
- Each student is endowed with a course passing probability p
- Course outcomes are independent
- Students graduate when they pass $n_{grad} = 42$ courses (125 credits)
- Students who fail to graduate within $T_c = 6$ years must drop out of college.

Graduation Prospects

$g(p)$: the probability of earning enough credits for graduation in T_c years

$g(p) = \Pr(n_{T_c+1} \geq n_{grad} | p)$



Key points:

1. Graduation prospects rise sharply with p
2. At observed course passing rates, many students have very high or low graduation prospects

Endowments

$J = 200$ types

$\left(\hat{q}_j, \hat{z}_j, \hat{k}_j, \hat{m}_j\right)$ are drawn from a joint Normal distribution

$a = \hat{m}_j + \varepsilon_a$ (scaled to be $N(0,1)$)

$GPA = \hat{m}_j + \varepsilon_{GPA}$

Financial shocks ζ are drawn from a Markov chain

Fixed Model Parameters

- Utility is log
- Discount factor: $\beta = 0.98$
- Interest rate: $R = 1.04$
- Max time in college: $T_c = 6$
- $w_{coll} = \$7.60$ (NELS)
- $k_{min} = -\$19,750$ (Stafford loan limits)
- Each model course represents 2 courses in the data.
  - $n_{grad} = 21$ (125 data credits).
  - $n_c = 6$ (36 data credits).

Calibrated parameters

Parameter	Description	Value
Endowments		
μ_k, σ_k	Marginal distribution of k_1	$36,620; 29,787$
μ_q, σ_q	Marginal distribution of q	5,331; 3,543
μ_z, σ_z	Marginal distribution of z	3,154; 5,542
$\alpha_{m,z}, \alpha_{m,q}, \alpha_{q,z}, \alpha_{a,m}$	Endowment correlations	0.46; -0.04; -0.12; 2.87
$\alpha_{k,m}$	Correlation k_1, m	-0.21
$\alpha_{IQ,m}$	Correlation IQ, m	1.20
Shocks		
Δ_q	q shock ($)	1,684
p_v	Persistence of employment shock	0.51
π	Scale of preference shocks	1.197
π_E	Scale of preference shocks at entry	0.397
Lifetime earnings		
ϕ_{HS}, ϕ_{CG}	Effect of ability on lifetime earnings	0.155; 0.197
y_{HS}, y_{CG}	Lifetime earnings factors	3.91; 3.95
μ	Earnings gain for each college credit	0.010
Other parameters		
ρ	Weight on leisure	1.264
δ	Weight on consumption	0.612
U_{CD}, U_{CG}	Preference for job of type s	-1.08; -2.46
$\gamma_1, \gamma_2, \gamma_{min}$	Credit accumulation rate $p_(a)$	4.58; 2.10; 0.47

Endowment correlations

	IQ	a	m	q	z
IQ	1.00				
a	0.67	1.00			
m	0.72	0.92	1.00		
q	-0.13	-0.15	-0.16	1.00	
z	0.27	0.35	0.37	-0.21	1.00
k_1	-0.19	-0.25	-0.27	0.04	-0.06

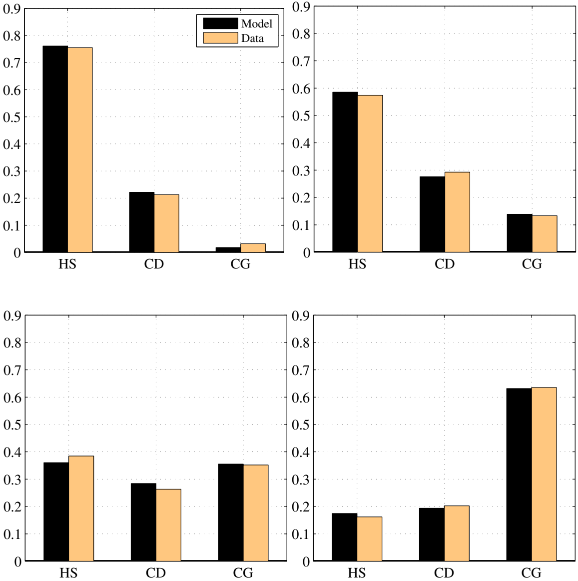
Fit: Credits

	Year 1		Year 2		Year 3		
Group	Model	Data	Model	Data	Model	Data	Mod
Dropouts	59.0	57.1 (1.0)	58.8	59.6 (1.0)	58.1	55.6 (0.9)	56.
Graduates	84.2	85.4 (0.6)	84.0	83.4 (0.5)	83.8	83.0 (0.4)	83.
GPA quartile 1	53.6	48.1 (2.3)	54.7	53.7 (2.3)	55.8	58.1 (2.3)	58.
GPA quartile 2	63.6	61.8 (1.6)	65.5	67.6 (1.4)	67.9	69.5 (1.4)	70.
GPA quartile 3	71.6	71.0 (1.2)	73.5	71.5 (1.0)	75.4	72.4 (0.9)	77.
GPA quartile 4	81.0	81.8 (0.9)	82.1	81.6 (0.7)	83.1	81.7 (0.6)	84.

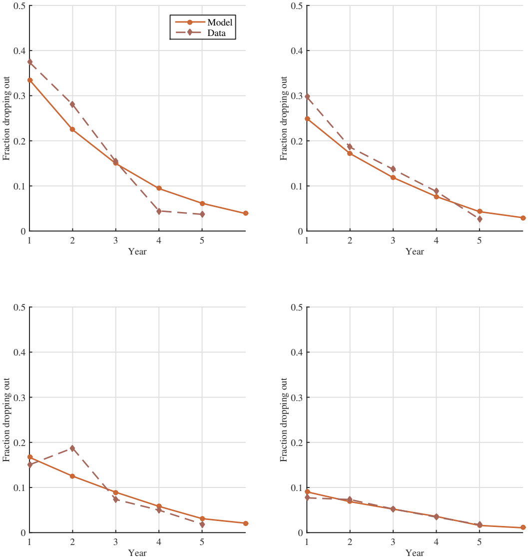
Fit: Credit Persistence

	Year $1-2$	Year $2-3$	Year $3-4$
Correlations, model	0.46	0.45	0.43
data	0.48	0.42	0.39
Eigenvalues, model	0.47	0.47	0.47
data	0.51	0.47	0.41
N	1665	1378	1196

Fit: Schooling and Test Scores



Fit: Dropout Rates



Fit: Debt

	Mean debt		Fraction with debt	
Year	Model	Data	Model	Data
1	3,674	3,511 (42)	16.1	26.1
2	5,750	5,945 (87)	26.7	34.6
3	8,043	7,871 (137)	48.7	41.0
4	10,183	9,486 (187)	53.8	47.4

Robustness

Model	Fraction with graduation probability < 0.20	> 0.80	Median welfare gain: Insurance within j	within (a,j)	Known ability
Baseline	0.24	0.30	0.22	0.05	0.14
Unrestricted $p(a)$	0.26	0.30	0.21	0.05	0.17
Wage shocks	0.25	0.29	0.21	0.08	0.13
$\pi = \pi_E = 0.1$	0.30	0.31	0.18	0.01	0.05
(η_c, m) correlated	0.24	0.31	0.21	0.04	0.14
$\theta = 1.5$	0.22	0.19	0.44	0.15	0.10
$\theta = 2.0$	0.20	0.18	0.57	0.18	0.10
$\theta = 4.0$	0.19	0.17	1.64	0.84	0.80

Akyol, A., and K. Athreya (2005): "Risky higher education and subsidies," *Journal of Economic Dynamics and Control*, 29(6), 979 – 1023.

Chatterjee, S., and F. Ionescu (2012): "Insuring Student Loans Against the Financial Risk of Failing to Complete College," *Quantitative Economics*, 3(3), 393–420.

Garriga, C., and M. P. Keightley (2007): "A General Equilibrium Theory of College with Education Subsidies, In-School labor Supply, and Borrowing Constraints," Mimeo. Federal Reserve Bank of St Louis.

Johnson, M. T. (2013): "Borrowing Constraints, College Enrollment, and Delayed Entry," *Journal of Labor Economics*, 31(4), pp. 669–725.

Keane, M. P., and K. I. Wolpin (1997): "The career decisions of young men," *Journal of Political Economy*, 105(3), 473–522.

References II

Manski, C. F. (1989): "Schooling as experimentation: a reappraisal of the postsecondary dropout phenomenon," *Economics of Education Review*, 8(4), 305–312.

Stange, K. M. (2012): "An Empirical Investigation of the Option Value of College Enrollment," *American Economic Journal: Applied Economics*, 4(1), 49–84.

Trachter, N. (2014): "Stepping Stone and Option Value in a Model of Postsecondary Education," *Quantitative Economics*, forthcoming.