How do Stipends Affect the Supply of PhD Scientists and Engineers?

NBER Science and Engineering Workforce Project

Preliminary Report:
Tanwin Chang, Hanley Chiang, Jason Abaluck, and Richard Freeman, with thanks to Dan Stanzione

June 17, 2004
NSF, Washington DC

Stipends: Modes of Funding During Graduate Education

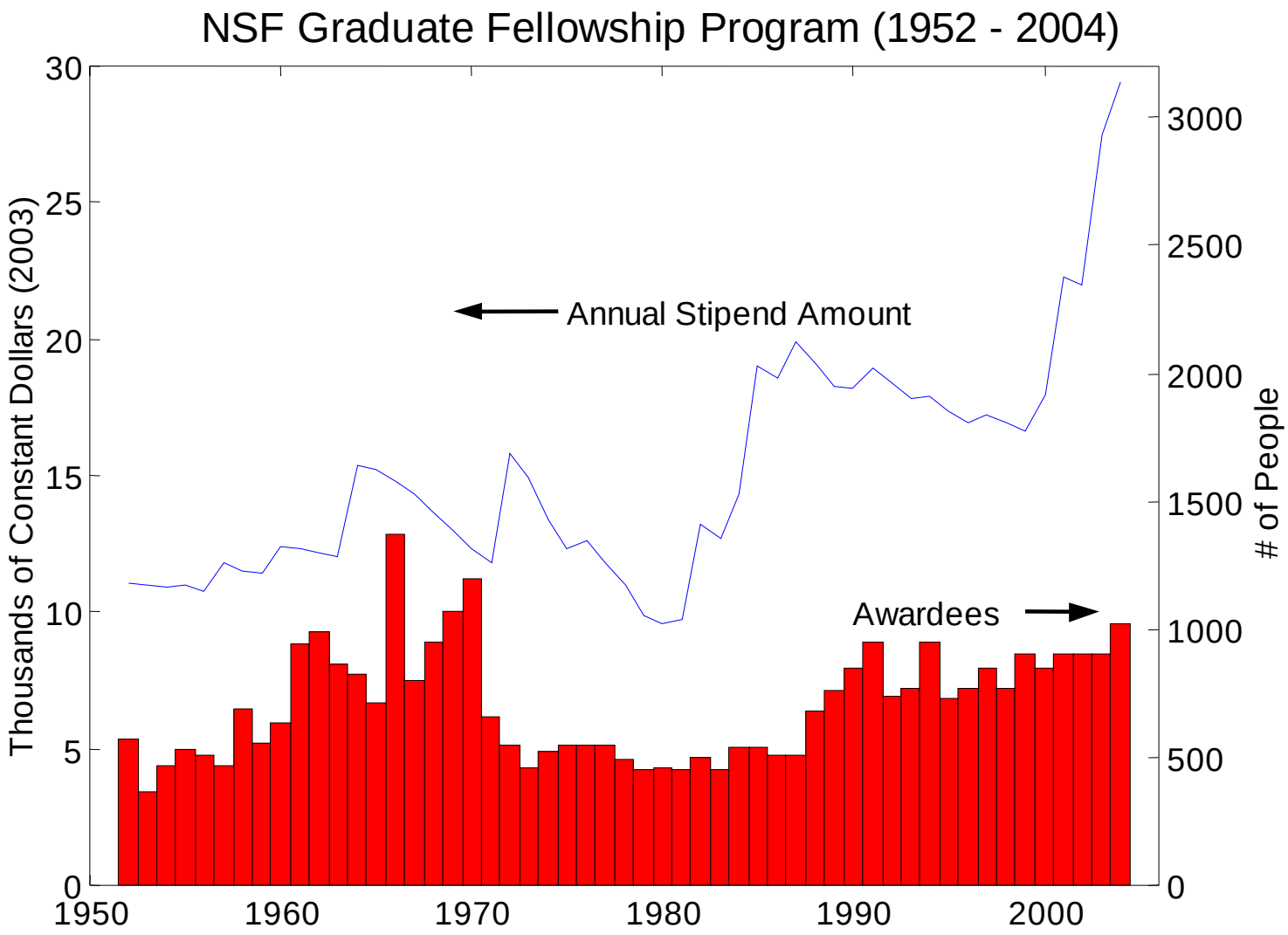
- Regular payments to student
- Three main types of stipends
  - *Fellowships*: competitive awards, usually no work requirement
  - *Teaching Assistantships*: teaching required
  - *Research Assistantships*: research required
- Multiple Funders
  - Government: NSF, NIH, etc.
  - Universities, Foundations, Individuals
- Postdocs may receive stipends, often via fellowships

- Other forms of funding
  - Self-financed: savings/family
  - Loans
  - Traineeships

Potentially Important Supply-Side Policy Tool Because:

- Time in graduate school/postdoc represents ~ ¼ of a scientist's career. (6 years grad school + 4 years postdoc = 10 years out of 40 year career)
  - Salary over first ¼ will have a non-trivial effect on lifetime earnings – larger than later $ because of discounting
  - Signalling effect to student can also be important
- Government fellowships may be restricted to citizens/permanent residents, primarily affecting US individuals
- Quantity and price dimensions – policy can alter number of awards and value of awards

The Number and Constant Dollar Value of NSF GRFP Stipends Vary over Time

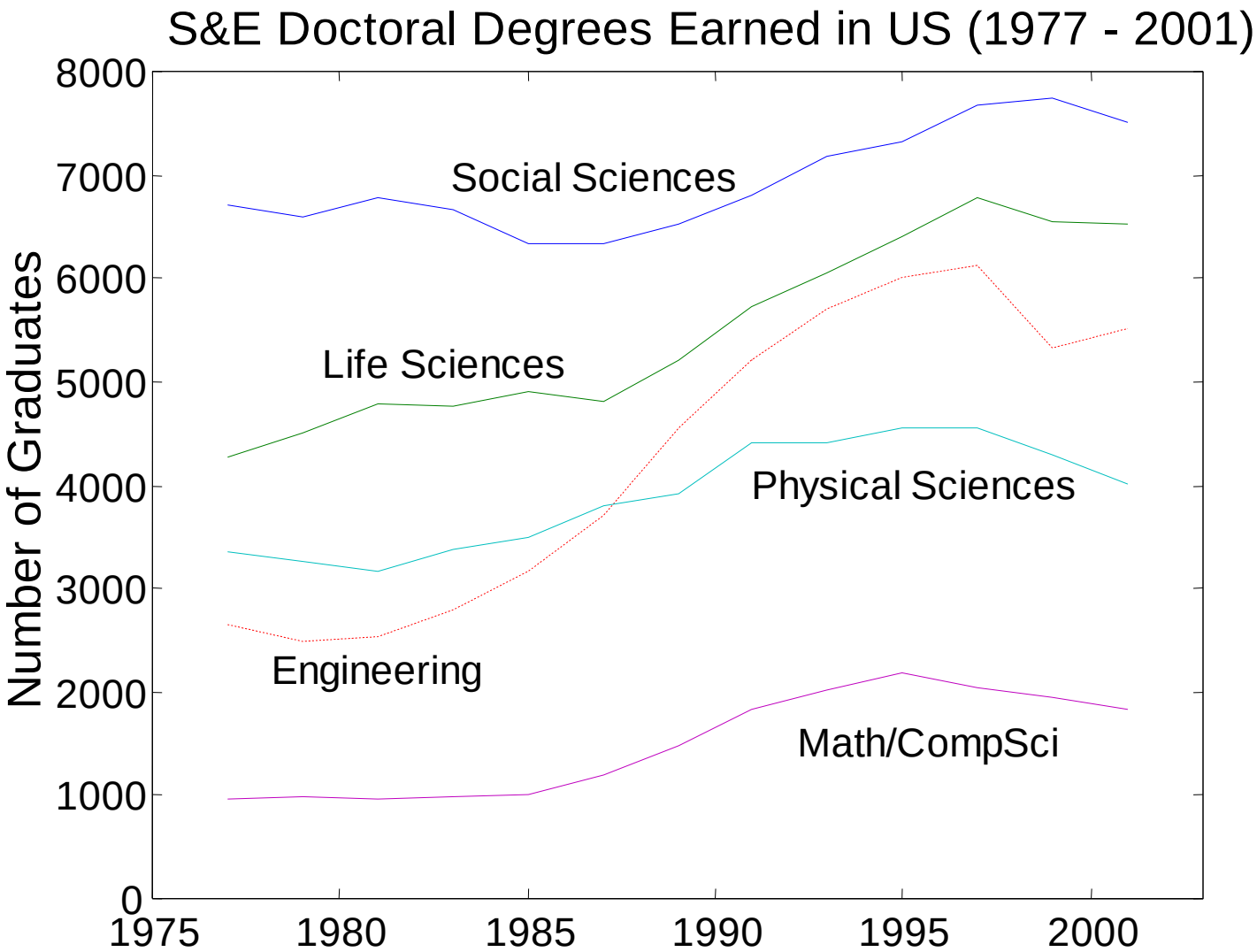


Awards to Students across Universities and Departments Vary Greatly, 1987-1999

	Standard deviation of log($ of stipends)			
	Within university at a department		Across universities and departments	
	1987/88	1999	1987/89	1999
TA Stipends	1.08	1.22	0.20	0.25
RA Stipends	1.20	1.24	0.16	0.23
Post-docs	-	-	0.37	0.54

Source: Nebraska Survey of Stipends

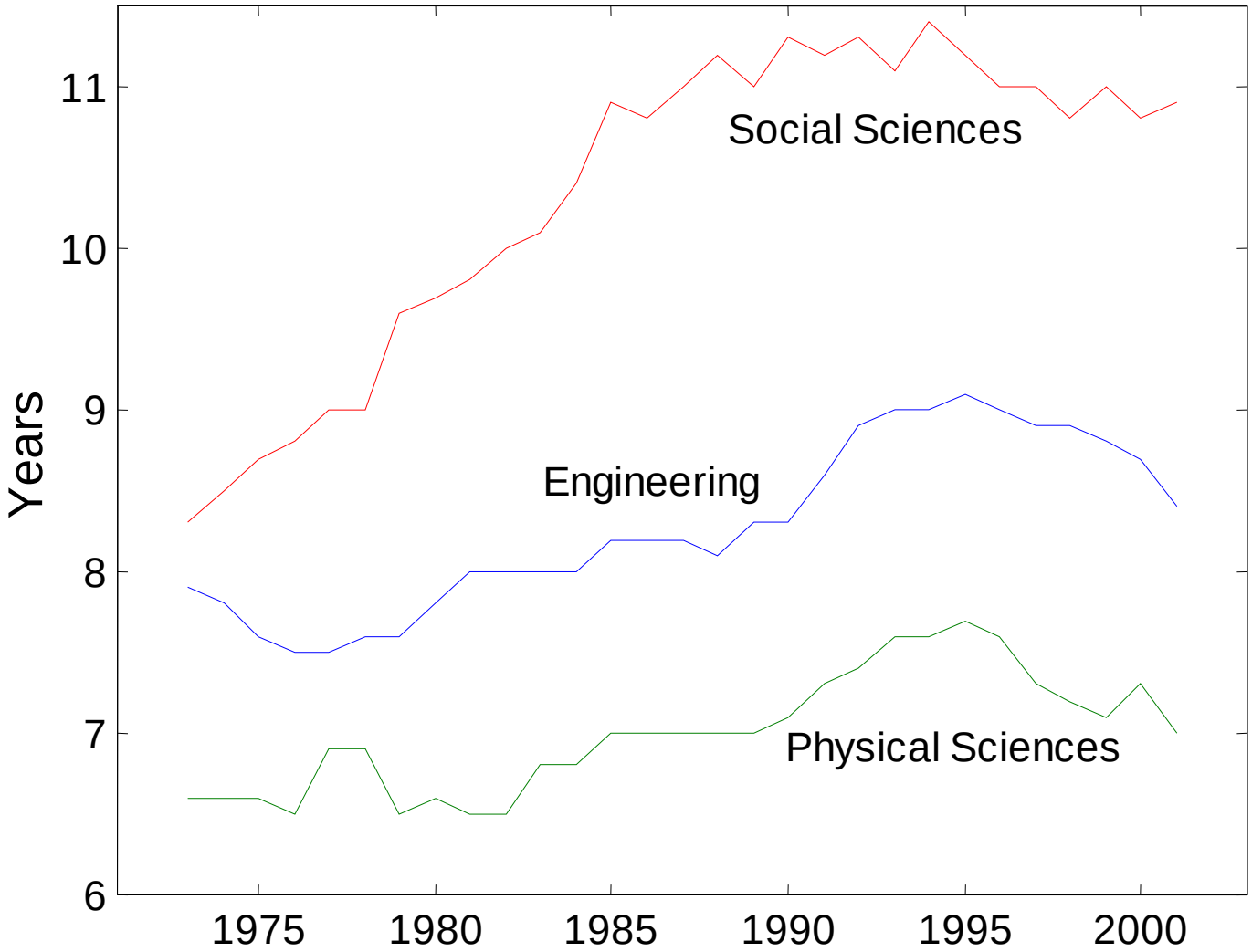
Numbers of PhDs Granted Varies Over Time and Among Fields



Source: NSF WebCASPAR (published in *Science and Engineering Indicators 2004*)

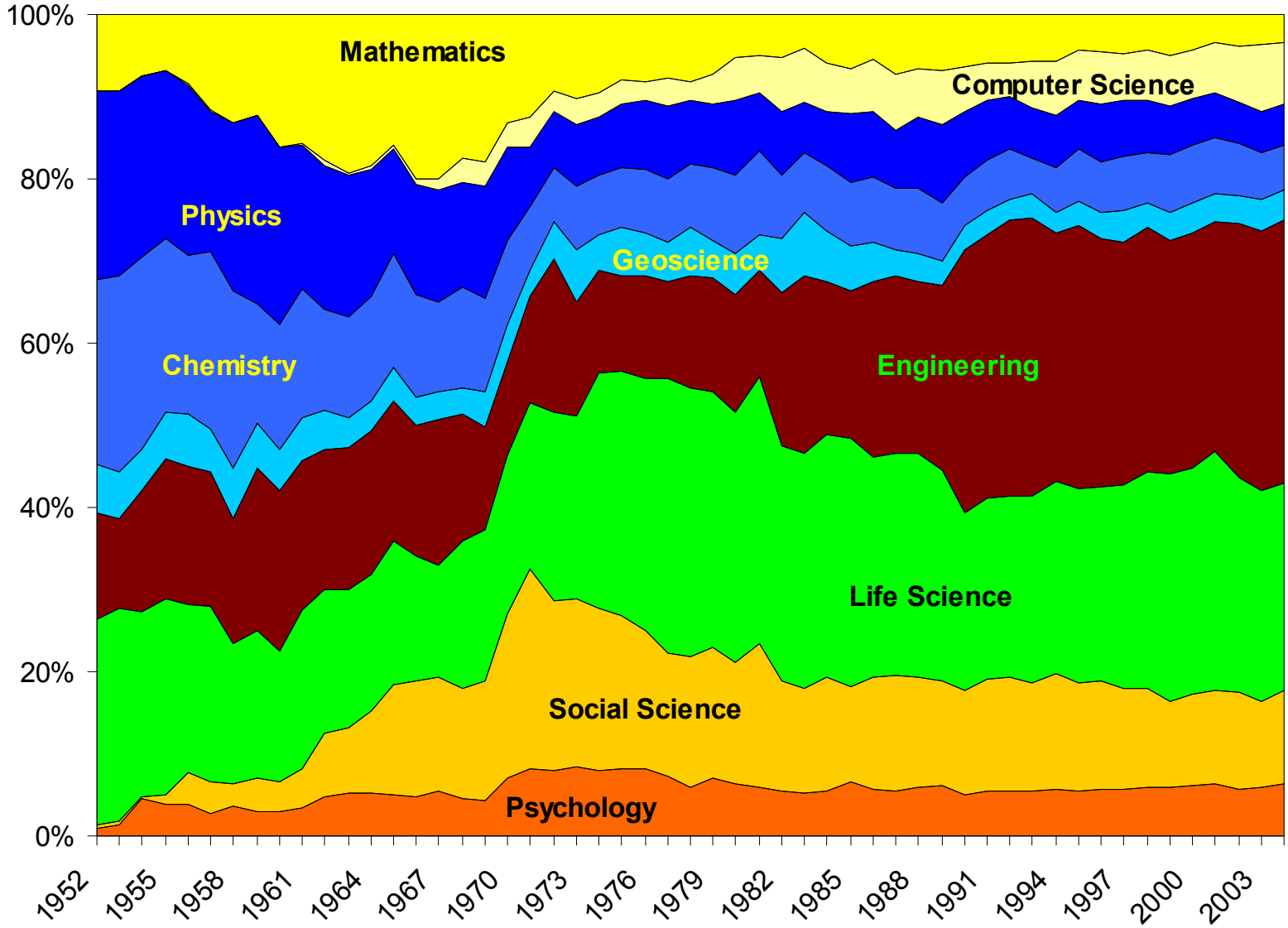
Variation in Time to Doctorate Degree

Median Time from Bachelors to PhD: Selected Fields (1973 - 2001)

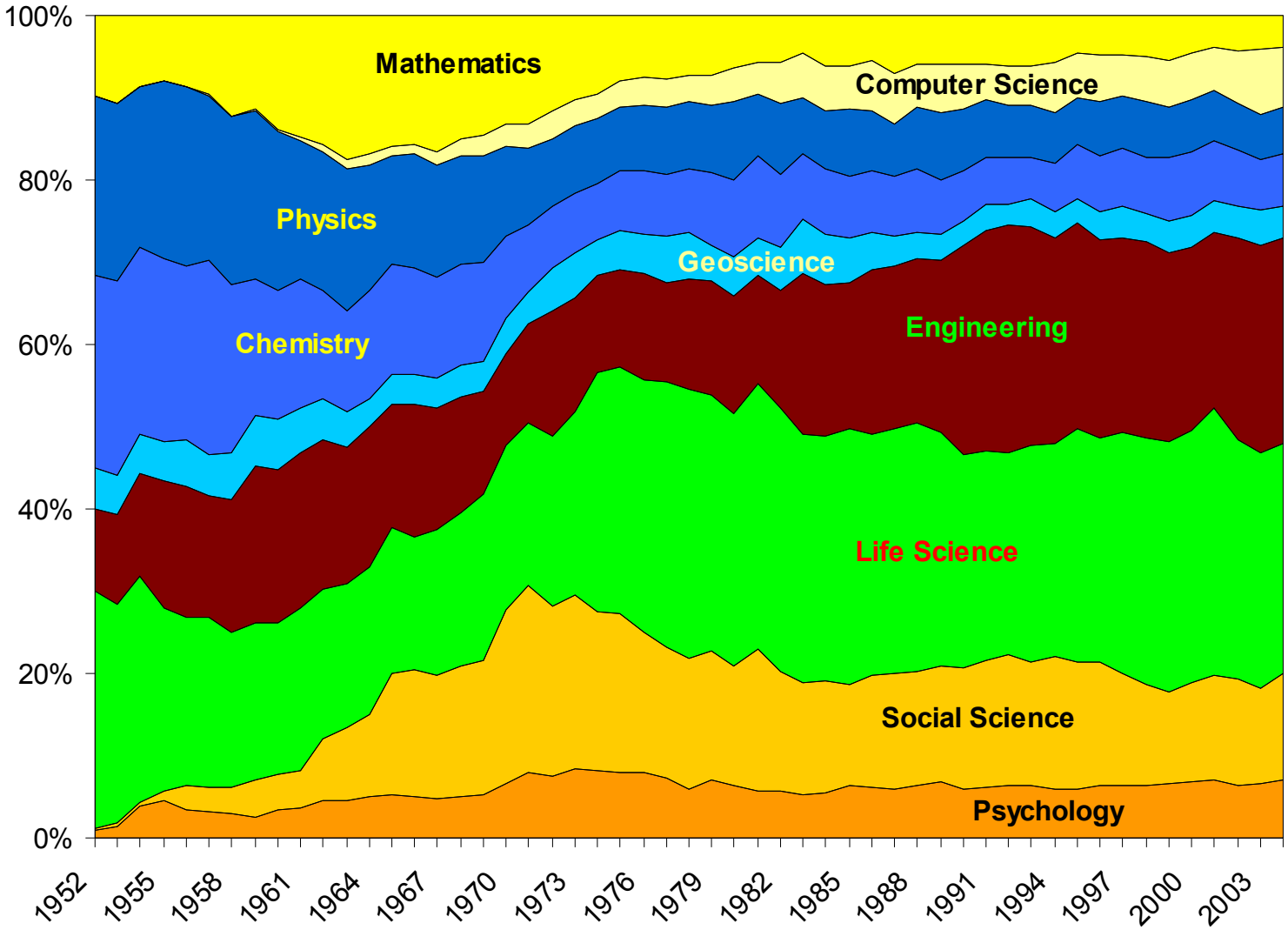


Source: NSF WebCASPAR (published in *Science and Engineering Indicators 2004*)

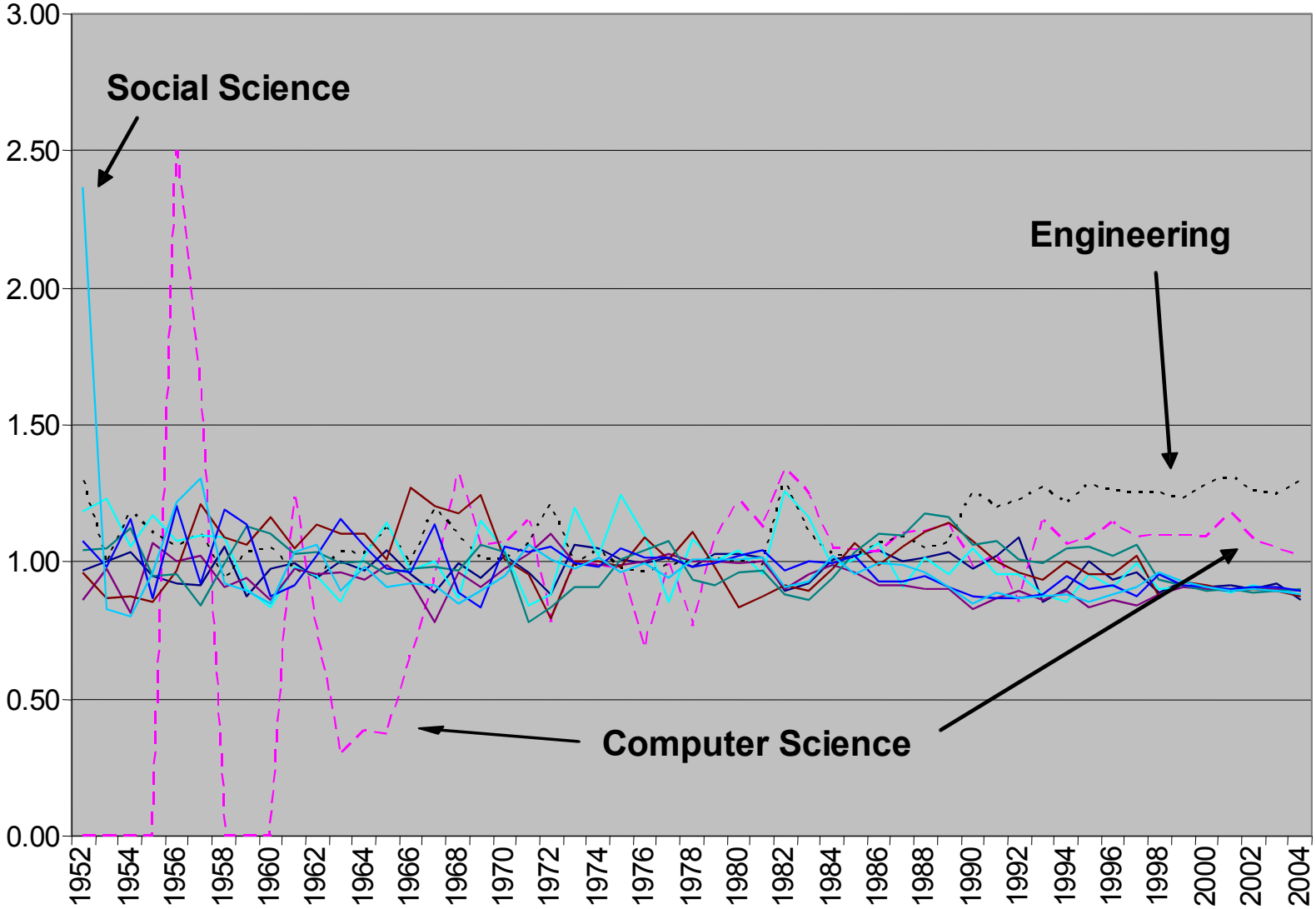
Huge Changes in Distribution of GFRP Awardees by Field: Decline of Physical Sciences



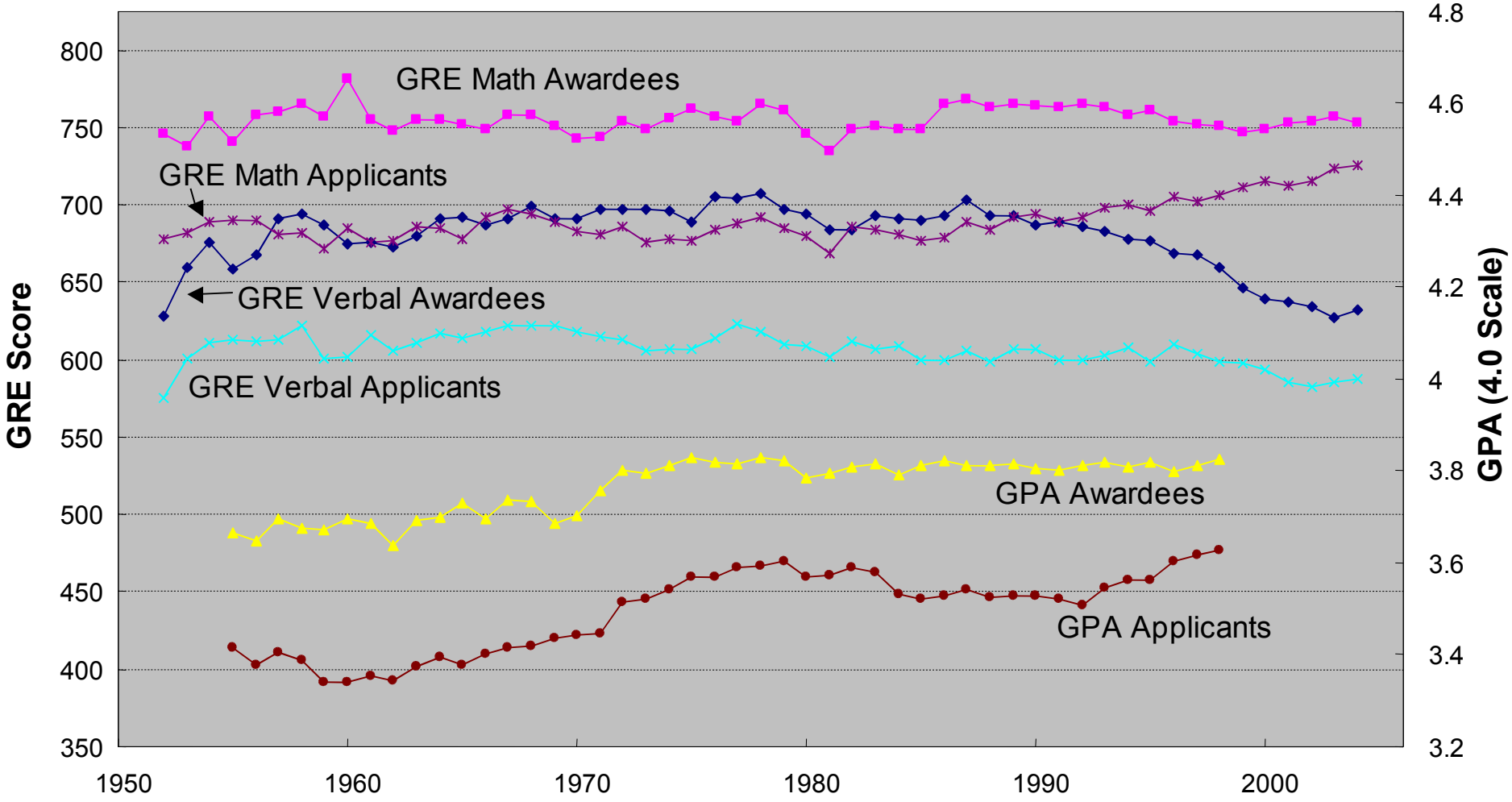
Because of Changes in Applicants by Field



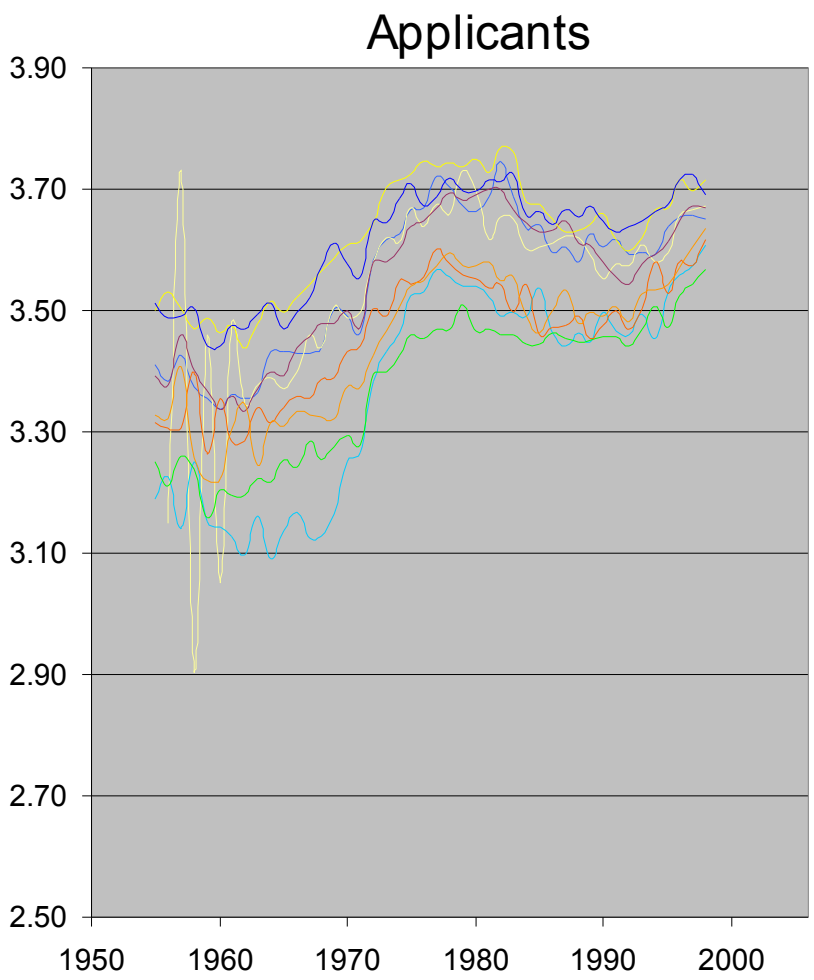
Proportion of Applicants Gaining Awards by Field Normalized by Overall Proportion (1952 – 2003)

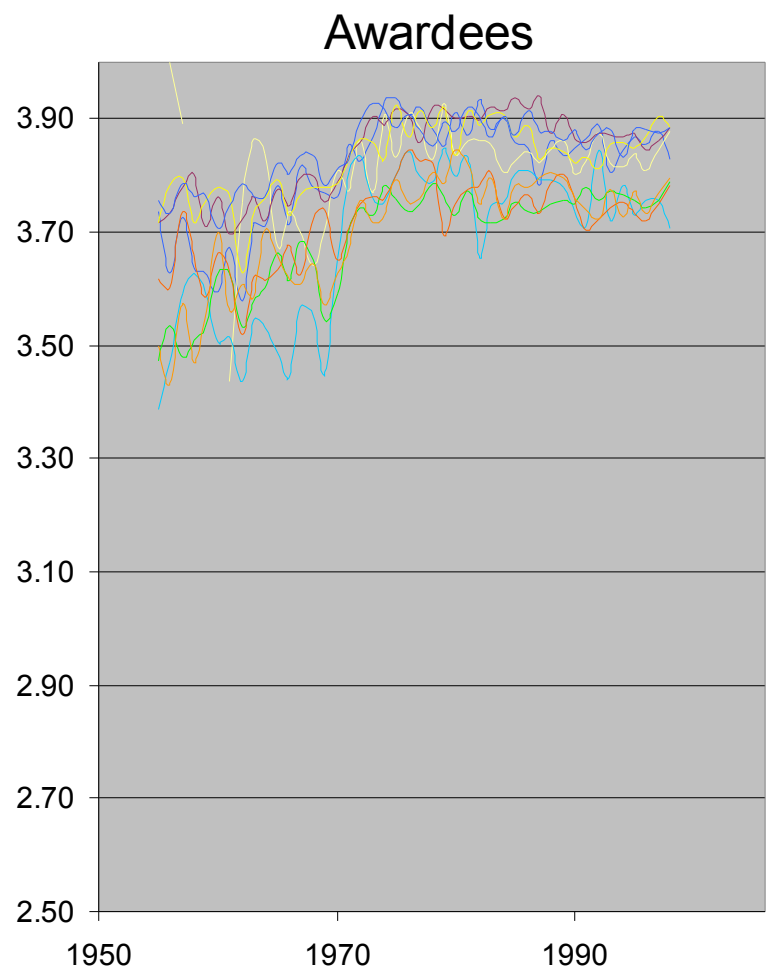


Trends in Mean Quality Measures of GRPF Awardees and Applicants (1952 – 2003)

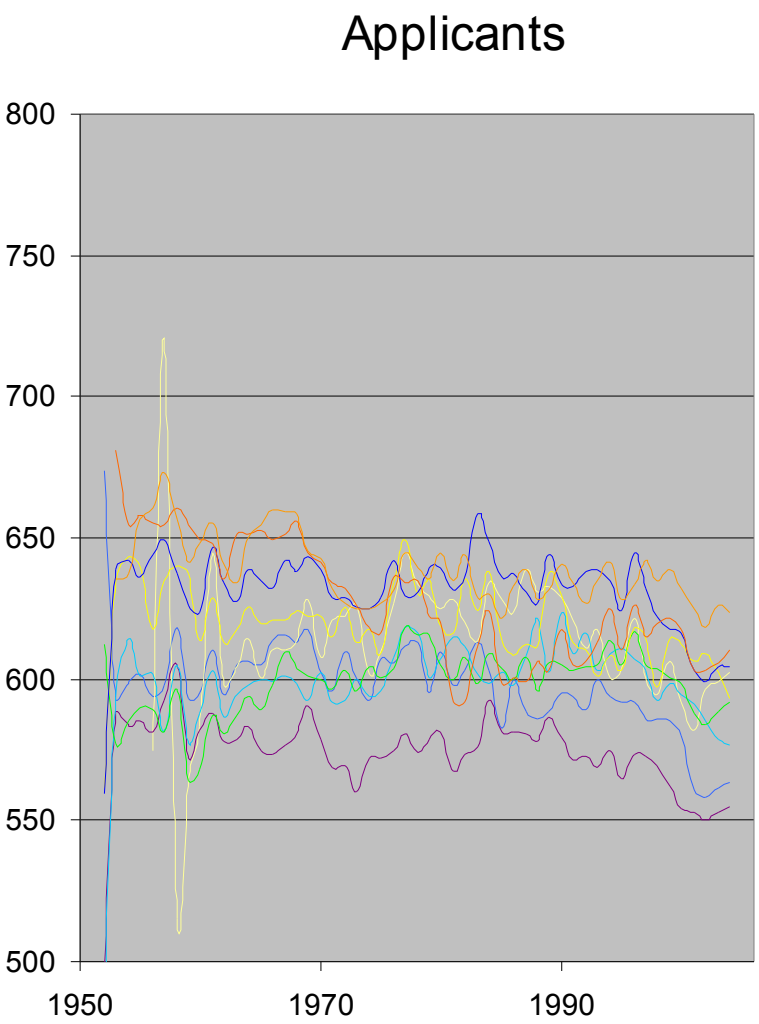


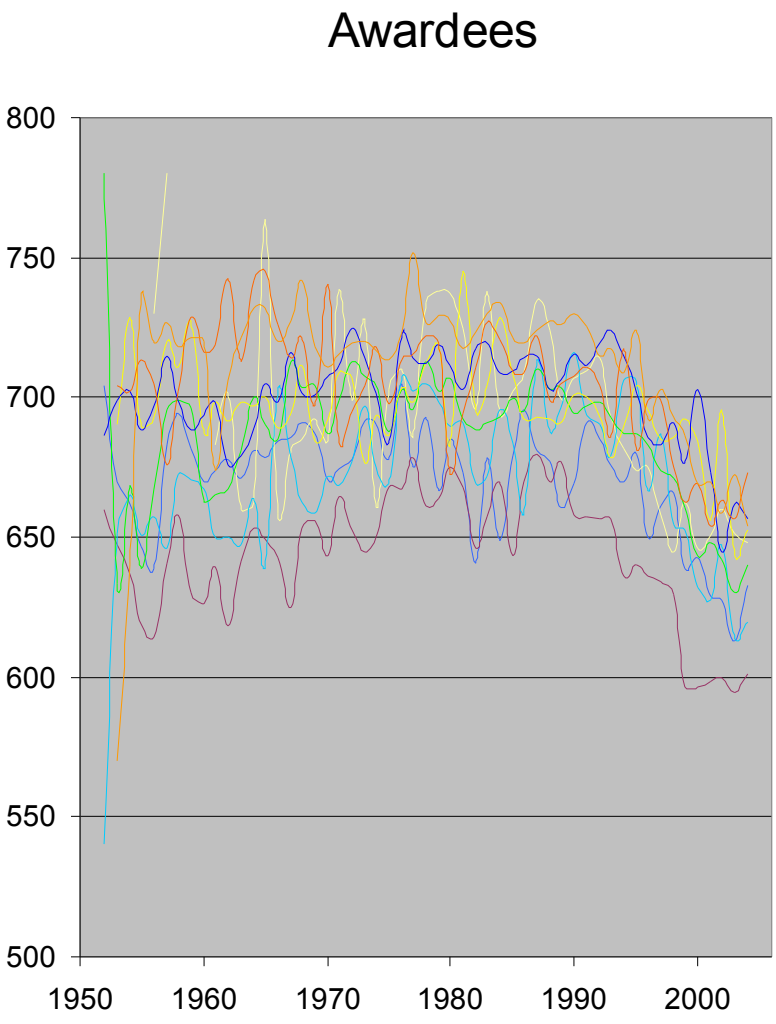
Trends in Mean GPA by Field (1952 – 2003)



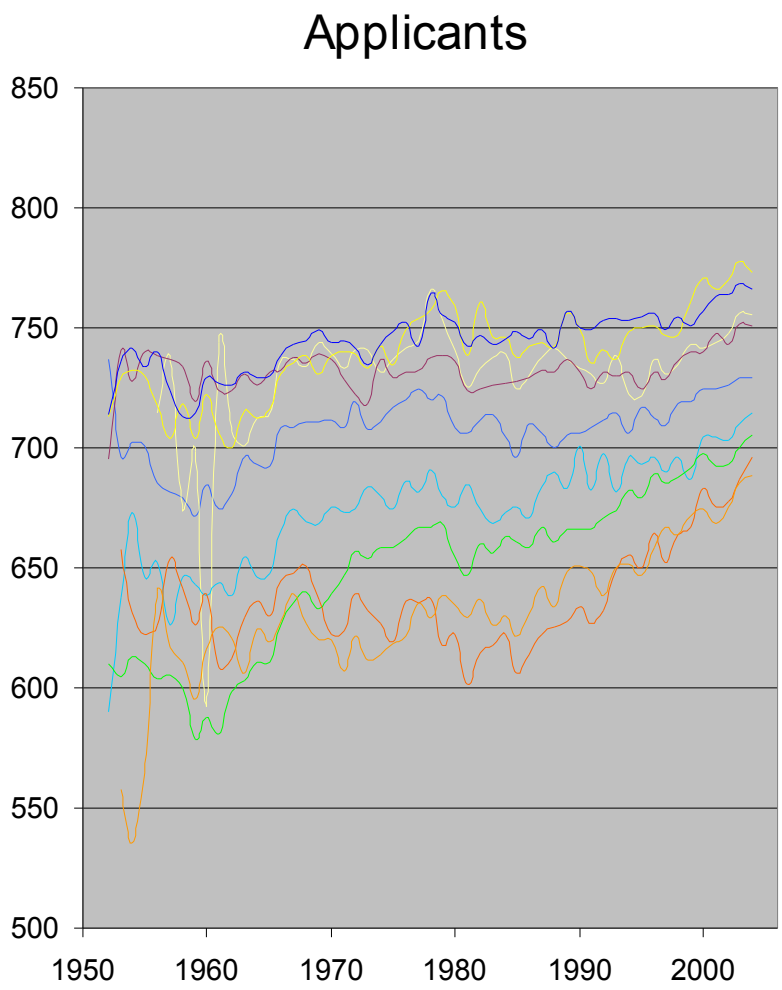


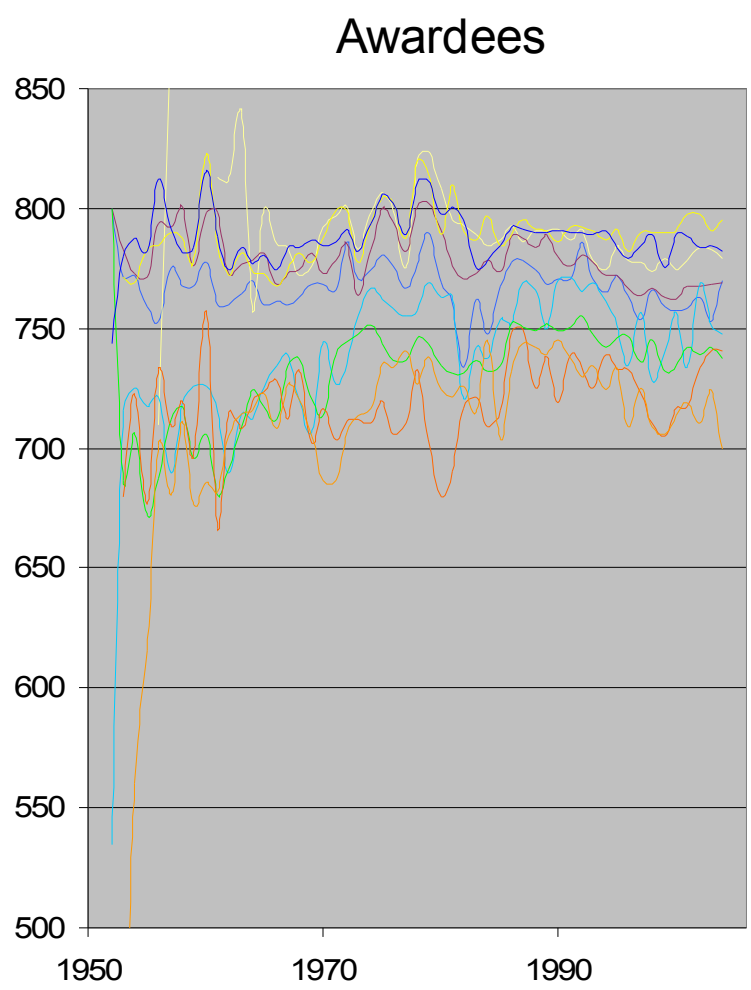
Trends in Mean GRE Verbal by Field (1952 – 2003)



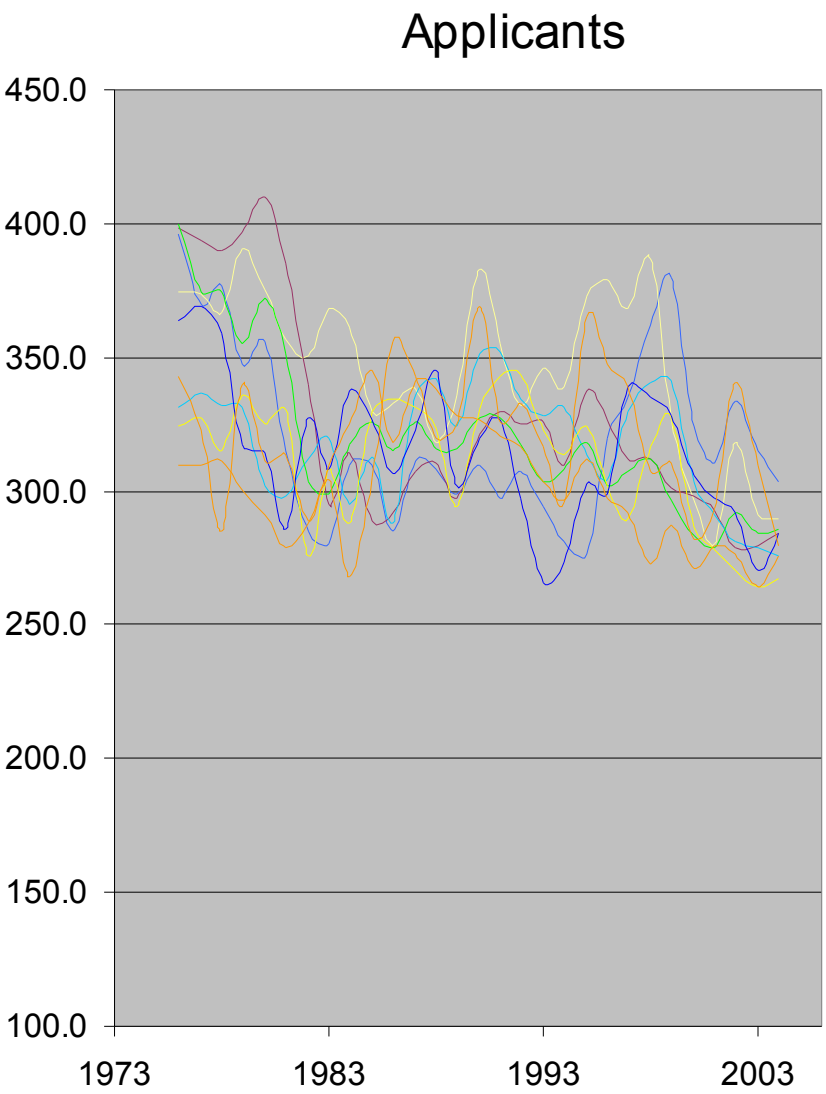


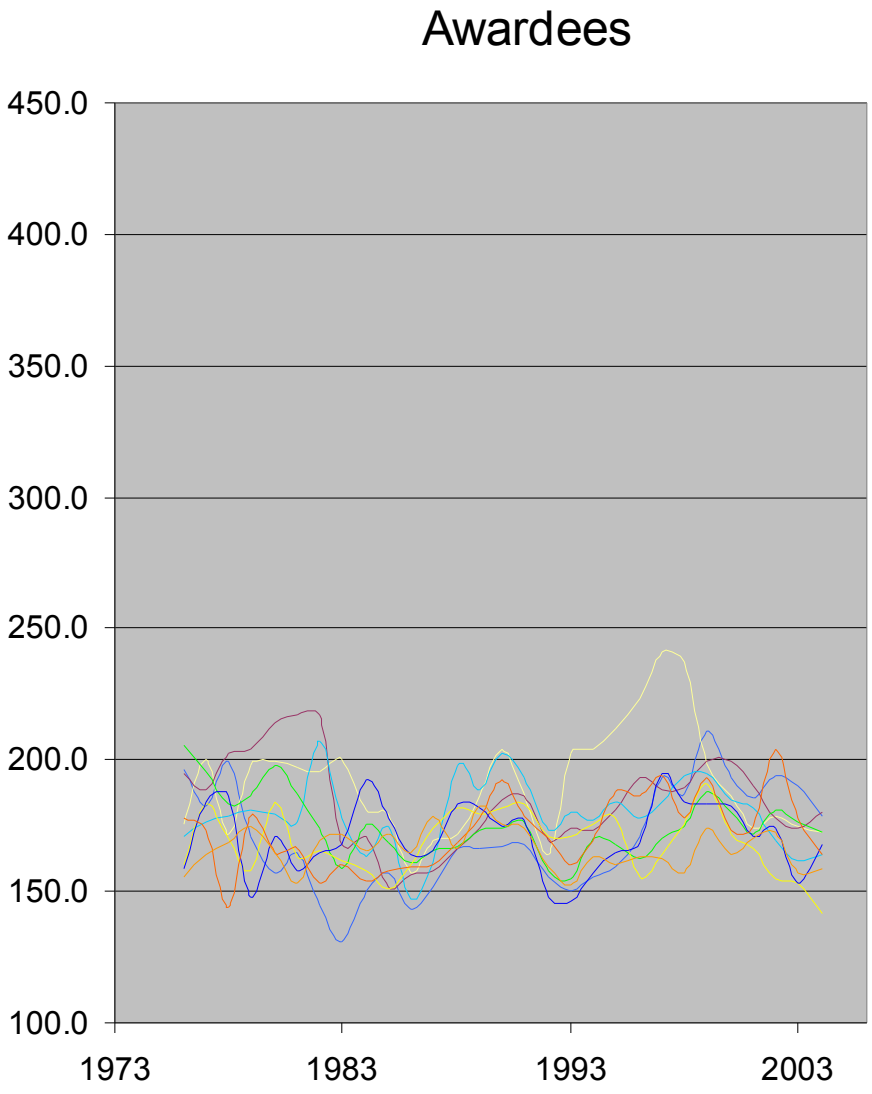
Trends in Mean GRE Quantitative Scores by Field (1952 – 2003)





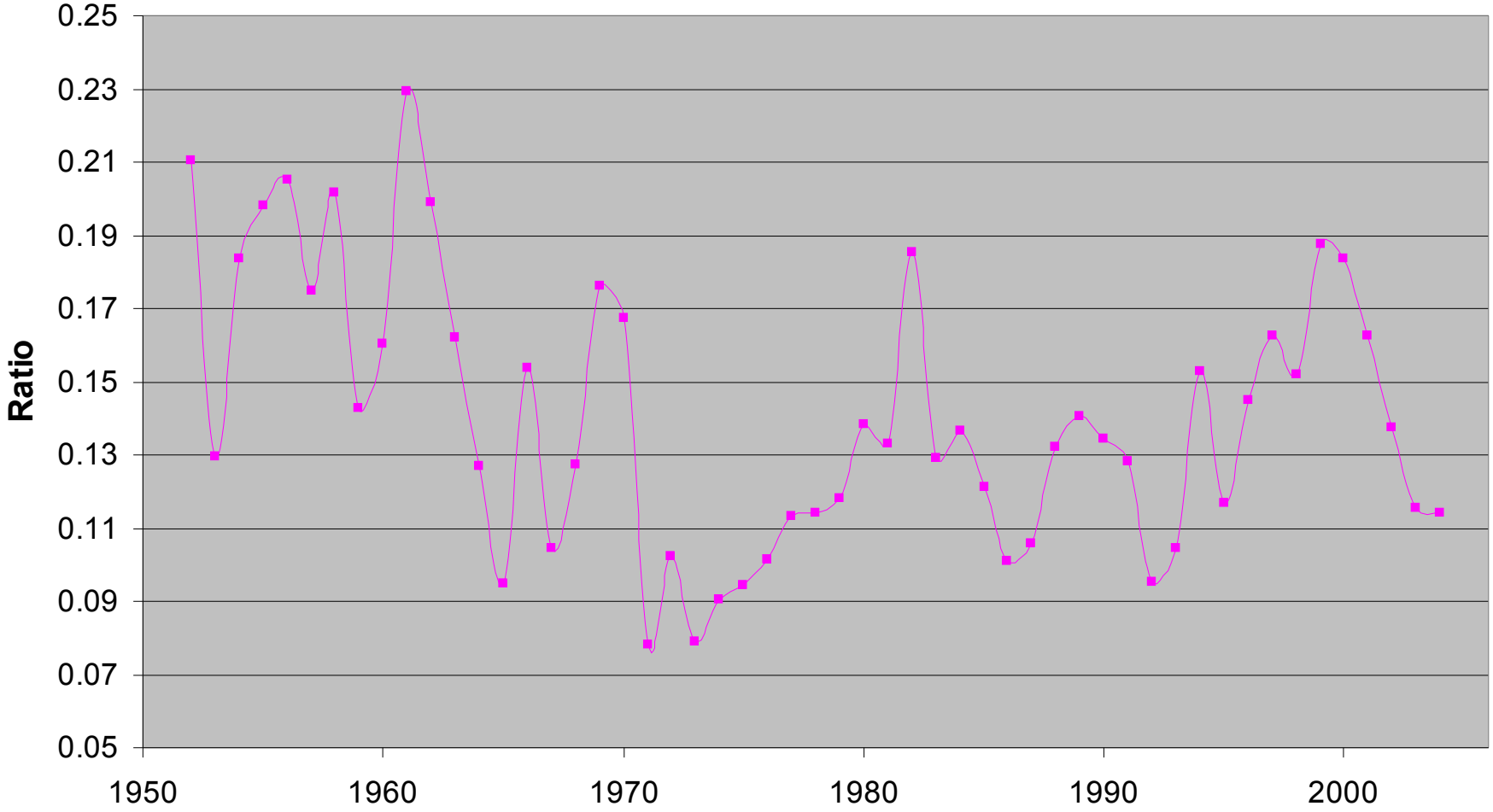
Trends in Mean Panel Rating by Field (1952 – 2003)



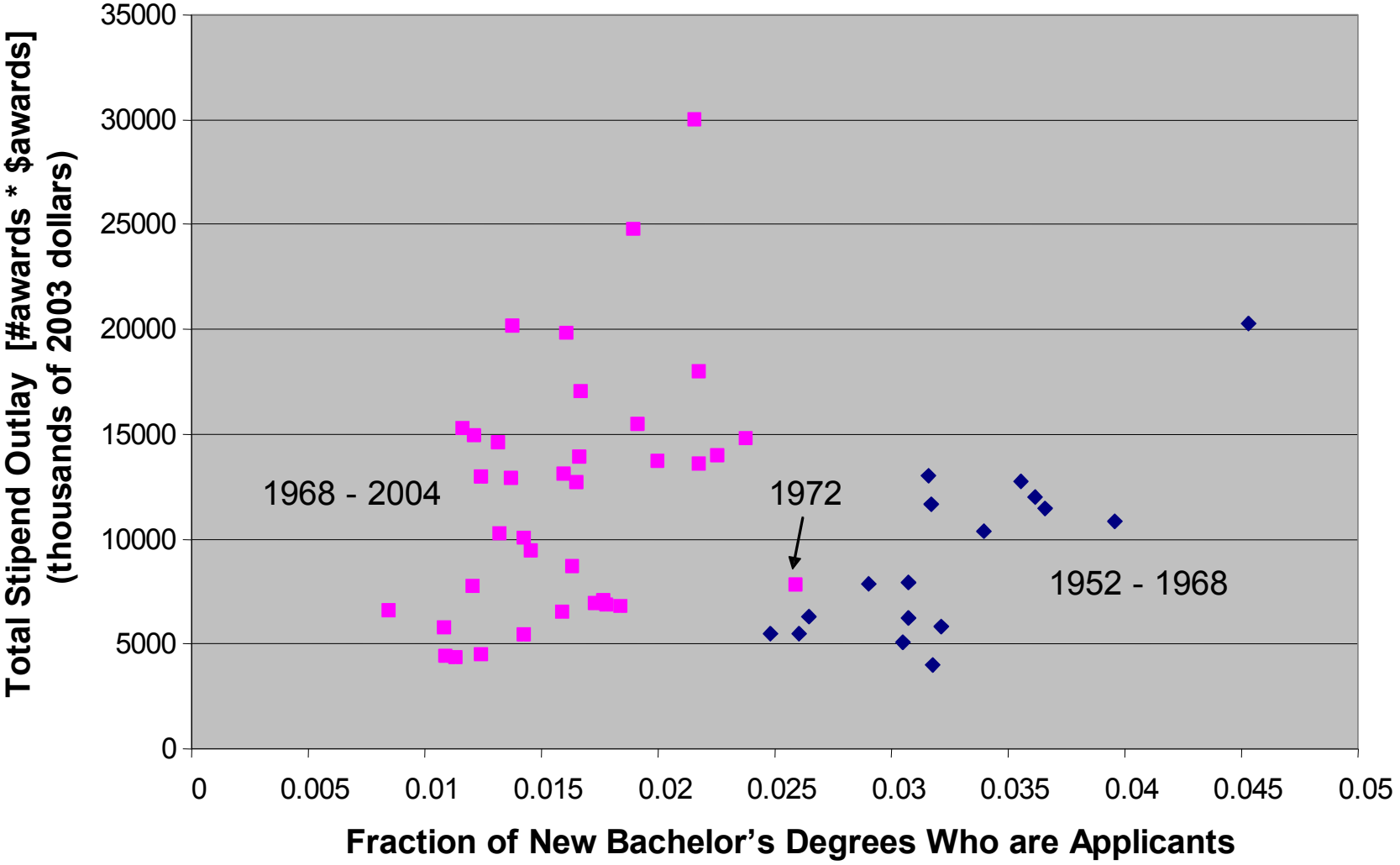


Lower score denotes higher applicant quality

Trends in Awards/Applicant (1952 – 2004)



Result (2) Total Funding for GRFP Stipends has Systematic Relationship to Number of Applicants



Analyzing the effect of changes to stipends on S&E workforce: Quantity (N) and Quality (Q)

When the number or value of awards changes

- What happens to the number and quality of applicants, awardees, and graduates?
  - $N = S_N(\#awards, \$awards, X)$
  - $Q = S_Q(\#awards, \$awards, X)$
- What happens to time-to-degree?
  - $TTD = S_{TTD}(\#awards, \$awards, X)$
- (How does the market adjust?
  - Effects on other forms of support
  - Long term impacts as *stipends* → *supply* → *salaries*.)

“Roy Model” focuses on the abilities of those on the margin between S&E and alternatives:

Key issue is how students on margin compare to those in the field: whether correlation of SE skills is +- with skills in alternatives; also dispersion of skills for SE vs other fields can affect choice.

- **When SE skills are negatively correlated with skills in alternatives; increased number of awards from applicant pool →reduced average ability because marginal entrants have lower relative ability than the committed people already in the occupation.**

- **Uncertain if skills are positively correlated. Counterexample of superstar who is best at everything**

- **Model can fail if less able love SE no matter what**

Data for Analysis

- **Applicant Data from the NSF Graduate Research Fellowship Program (GRFP) 1952-2004**
  - *Cumulative Index (CI),* 1952 – 1993
  - Recent data collected by NSF and contractors, 1994 – 2004
  - Contains GRE scores, GPAs, Panel Ratings, Demographic info
  - Altogether info for more than 200,000 applicants
- ***Survey of Earned Doctorates*, an annual survey administered to all new doctoral recipients from US institutions**
- **Data on institutions first published in "Research-Doctorate Programs in the United States, Continuity and Change" (1993)**
  - departmental level statistics over a 5 year period (1988 – 93)
  - Info on 3,634 doctoral programs at 274 US universities
  - Obtained via WestED (who cited it in publication NSF 02-080)
- **Various and Sundry other sources**

Research Strategy

Treat variation in # and $ NSF awards as exogenous

Examine individual records; aggregate time series; pooled cross-field time series

Key Correlations – quality and quantity

Quality and awards/applicants (expected negative)

applicants and $ awards (expected positive).

quality of awardees and $ awards (uncertain/hopefully positive)

Examine effects of stipend support on time to degree.

Eventually examine other market incentives; compare field differences over time

Current Tentative Findings

1. Stipends reduce Time to Degree
   1. Cross-departmental data over time
   2. Individual data on SED

2. Avg Quality Declines With Awards/Applicant

4. No clear pattern of quality with $ awards

4. Criterion for awards depends on applicant quality

Result 1: Coefficients on Time to Degree among Individuals, SED, 2001-2002

	Yr of PhD degree Minus Yr entered PhD program	Yr of PhD degree Minus Yr Entered Any Grad
Impact of:		
Fellow/Grant	**-0.67 (.11)**	**-1.51 (.18)**
RA	**-0.57 (.11)**	**-1.50 (.17)**
TA	**-0.35 (.12)**	**-1.49 (.18)**
Self-financed	**deleted group**	
N	**26,932**	**14, 873**

All calculations include 21 field dummies and 346 university dummies

Result 1: Coefficients on PhD Year – First Year Entry to Grad School Among Individuals, Department-Level Estimation

Impact of:	1981-85	1993-7	1998-01	Panel ('97-'01)
Fellow/Grant	-1.4	-1.4	-1.9	-1.5
RA	-2.2	-1.5	-1.5	-1.1
TA	-1.3	-1.2	-1.7	-1.2
Self-financed	deleted group			
N	**3353**	**3767**	**3751**	**3444**

All calculations include controls for university and field

Comments

- Results exclude people who leave programs, conditional on PhD receipt
- Different measures of time to degree gives different coefficient sizes
- Self reported
  - Years between first entered graduate school and PhD
  - Years in coursework
  - Years on dissertation
- PhD year – year began any graduate work
- PhD year – year began PhD program

Results 2 and 3: Aggregate Time Series of Measures of Awardee Quality on Awards/Applicants and Stipend $

Dependent Variable (in *ln* form)	Explanatory Variable (in log form)	Coefficients	
Mean GRE Verbal	Ratio of Awards to Applicants	-.05**	-0.05*
	Stipend Value (adjusted by 4 year-college wage)		-0.02
Mean GRE Quant	Ratio of Awards to Applicants	-.02*	-.02*
	Stipend Value (adjusted by 4 year-college wage)		.02
Mean GPA	Ratio of Awards to Applicants	-.05**	-.05**
	Stipend Value (adjusted by 4 year-college wage)		.01

*significant at 5%; **significant at 1%
N=42

Results 2 and 3: Determinants of Average Awardee Quality, Cross-field, time series, 1952-2003 (all variables in *ln* form)

Measure Of Quality (Mean values over a year and field)	Awards/ Applicants	Applicants/ BSs in field	Stipend/ 4Yr college $
GRE math	-.026	-.006	.011
GRE verbal	-.035	-.003	-.017
GPA	-.024	-.018	.003
Reference Score	-.155	-.119	.145
Panel Rating	-.163	-.055	.066

Note: Reverse coded reference score/panel rating

Result 4: Determinants of the Average Quality of Awardees from a Given Field in a Given Year

		Dependent Variables (in log form)				
		Mean GRE Verbal	Mean GRE Quant	Mean GPA	Mean Reference Score	Mean Panel Rating
Explanatory Variables (in log form)	**# of Awards to field** (normalized by # of Applicants in field)	– 0.035**	– 0.026**	– 0.024**	-0.155**	-0.163**
	# of Applicants from Field (normalized by Bachelor's degrees granted in the US in field)	– 0.003	-0.006**	–0.018**	-0.119**	– 0.055**
	Stipend Value (adj. by 4 year-college wage, previous year)	– 0.017**	0.011**	0.003	– 0.145**	-0.066**

Reverse coded reference for score/panel rating.
*significant at 5%; **significant at 1%
Table summarizes the results of 5 regressions, each with 3 explanatory variables included plus Field fixed effects and Year Fixed Effects.

Results 4: Coefficients of Probability of Award on Measures of Applicant Quality

	Probability of Award	
GRE Quant	0.043**	-0.021**
GRE Verbal	0.064**	0.016**
GPA	0.1866**	-0.0156**
Reference Score		0.0027**
Panel Rating		0.0015**
N	209247	107565

GPA : 4 point scale,
GRE scores are on 2 to 8 scale.
Reference score is from 0 to 70.
Panel rating is from 100 to 900.
Reference Scores and Panel Ratings reverse coded.

*significant at 5%; **significant at 1%

NEXT STEPS

Analyse time to degree behavior using different measures; consider dropouts

Addition of measures of economic conditions in the fields

More rigorous modelling of impact of increased $, on quantity & quality.

How estimates could help assess “optimal stipend policy”? (Richard, tomorrow)

Your suggestions???