SYST/OR 699 Final Project

Modeling Cross-Agency Effectiveness of Science, Technology, Engineering and Mathematics (STEM) Programs

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Project Sponsor

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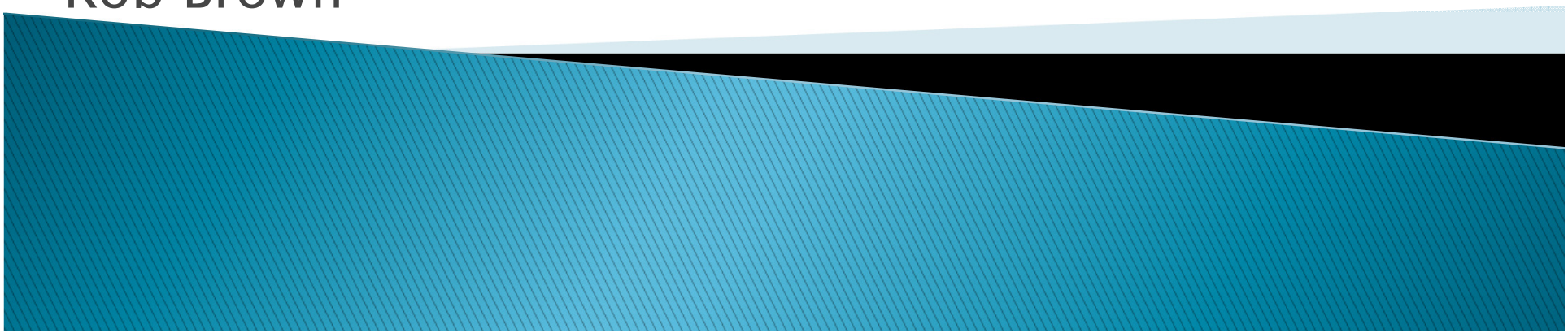


What is a Cross-Agency Goal?

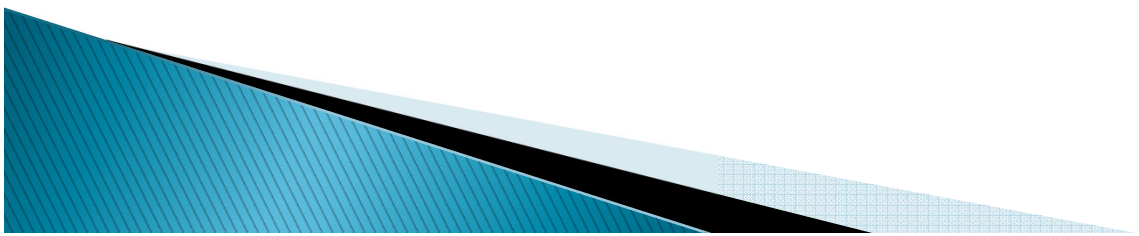
- Approach used to accelerate progress on Presidential priority areas
- To ensure effective leadership and accountability across Federal Government

Mission	Management	
Cybersecurity	Effectiveness	Customer Service
Climate Change		Smarter IT Delivery
Insider Threat and Security Clearance	Efficiency	Strategic Sourcing
Job-Creating Investment		Shared Services
Infrastructure Permitting Modernization		Benchmark and Improve Mission-Support Operations
STEM Education	Economic Growth	Open Data
Service Members and Veterans Mental Health		Lab-To-Market
		People and Culture

Source: Performance.gov

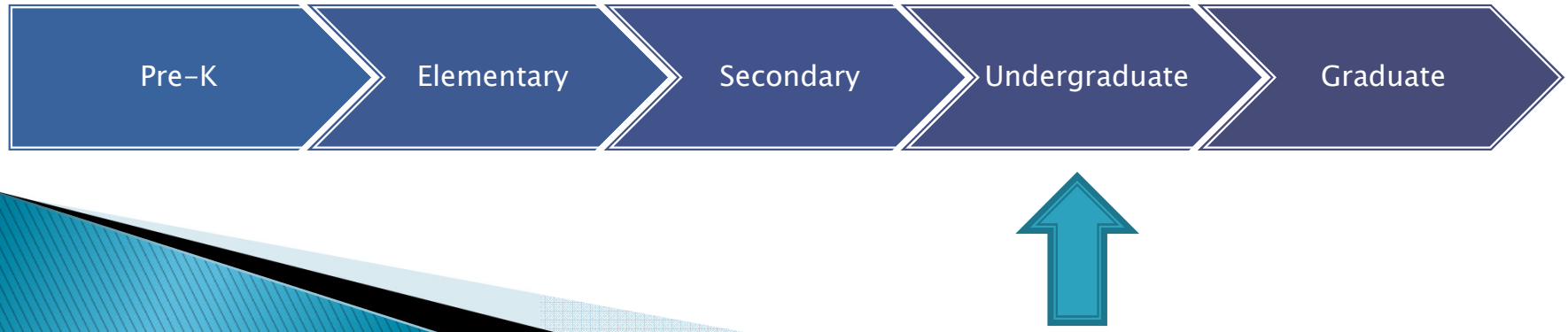
Problem Statement & Objectives

- **Problem:**
  - Government lacks way to assess effectiveness towards meeting cross-agency goals.
  - Limited performance data is publicly available.
- **Objectives:**
  - Develop a prototype model driven approach to increase proportion of STEM graduates.
  - Advise agencies regarding opportunities to improve investments and performance management.
  - Identify the challenges in developing an effective methodology, data inadequacies and critical needs, and recommended methodology improvements.



Scope Formulation

- Alignment of scope with STEM goal
  - 1 Million more STEM undergraduate degrees in 10 years (2010-2020)
- Factors affecting student attrition and persistence
- Create a model of the STEM student pipeline to assess the STEM cross-agency goal



STEM Funding Hierarchy

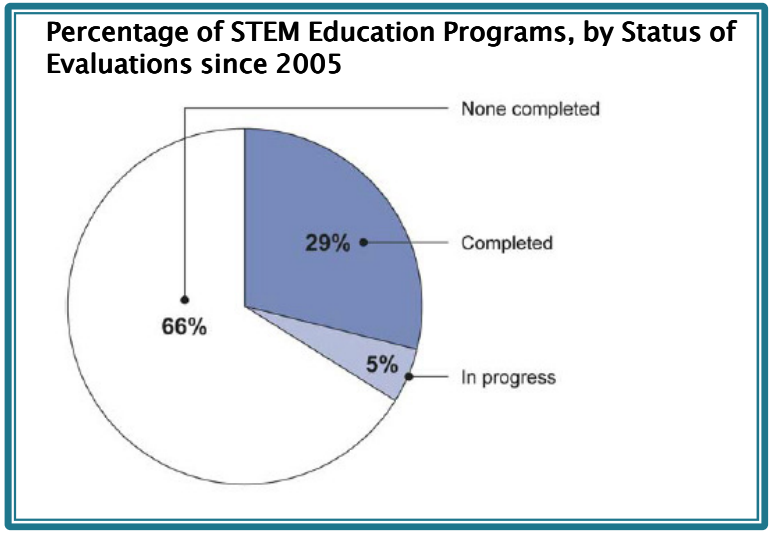
Government STEM Programs

Institutions / States

Students

Critical Literature Review

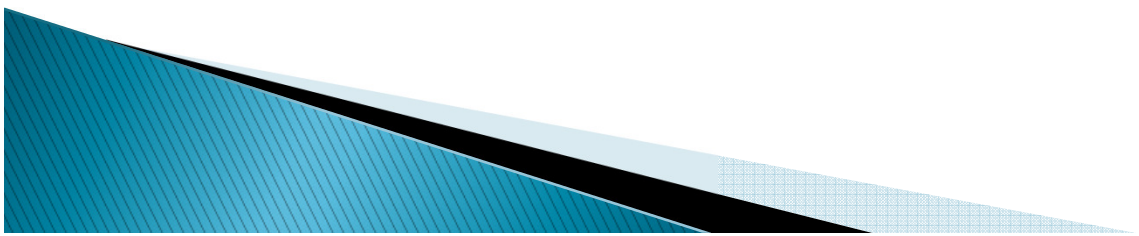
- STEM Programs
  - Institutional Grants
  - Scholarships to Students (Pell)
  - Engagement and Learning/Skill Development
- No standardized process to evaluate STEM Effectiveness (one-time studies)
- STEM program performance needs to be linked student level factors



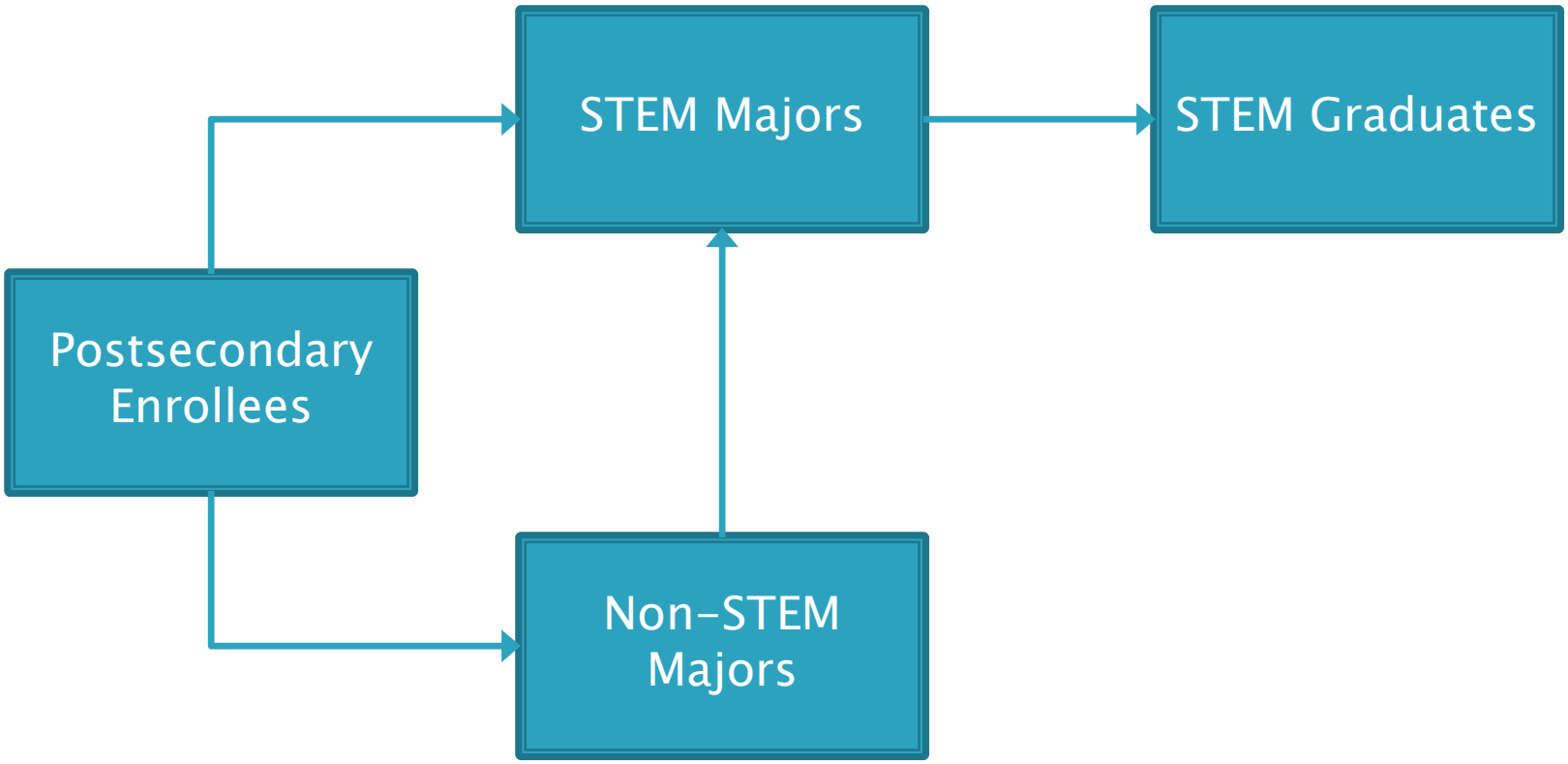
Source: GAO Report, April 2012

System Modeling

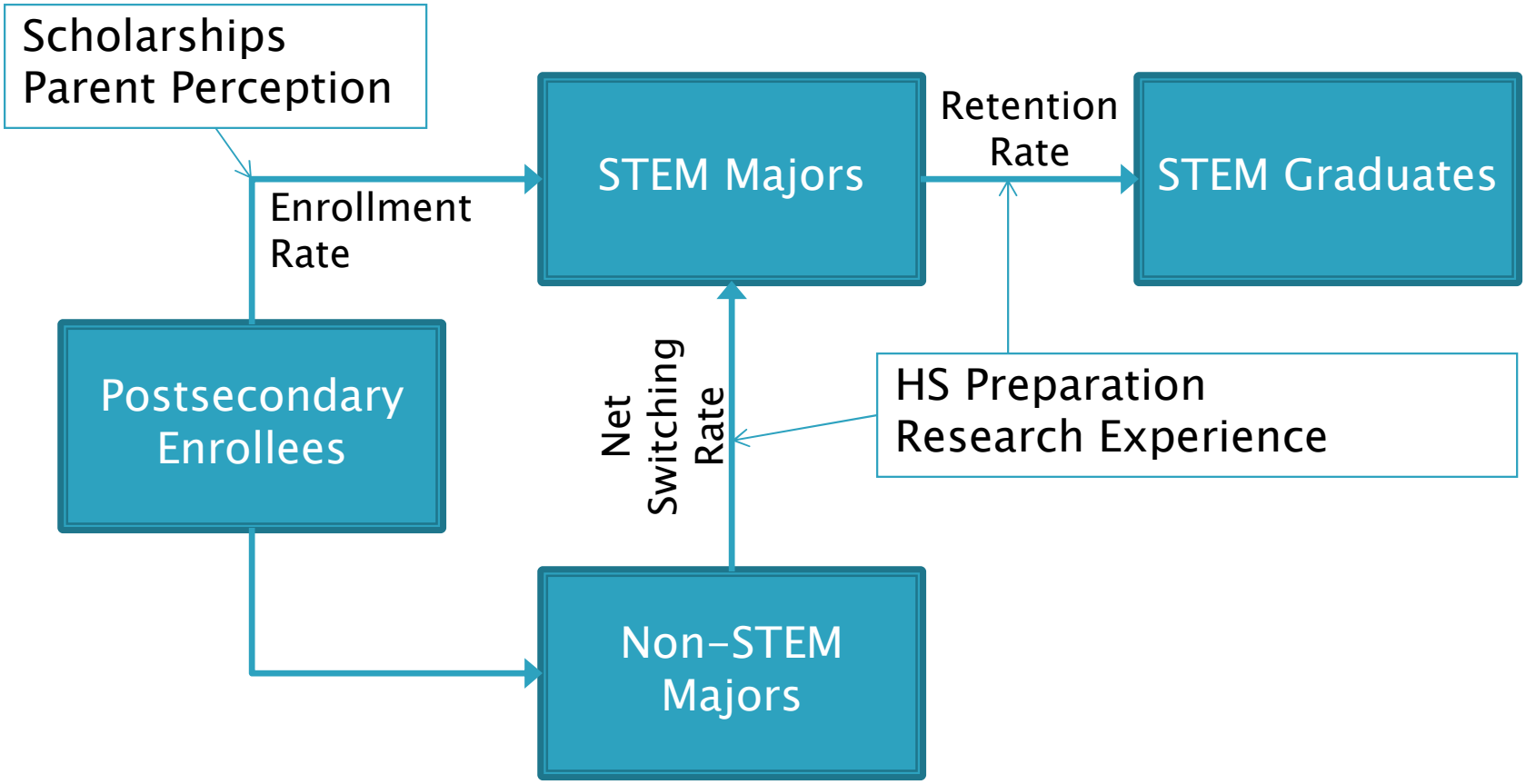
- Why a System Dynamics Model?
  - Capture non-linearity
  - Considers causality and delayed effects
  - Lack of data
- Factor based model of persistence and attrition of students in STEM pipeline
- Focus on undergraduate students
- Time-based simulation (10 years)



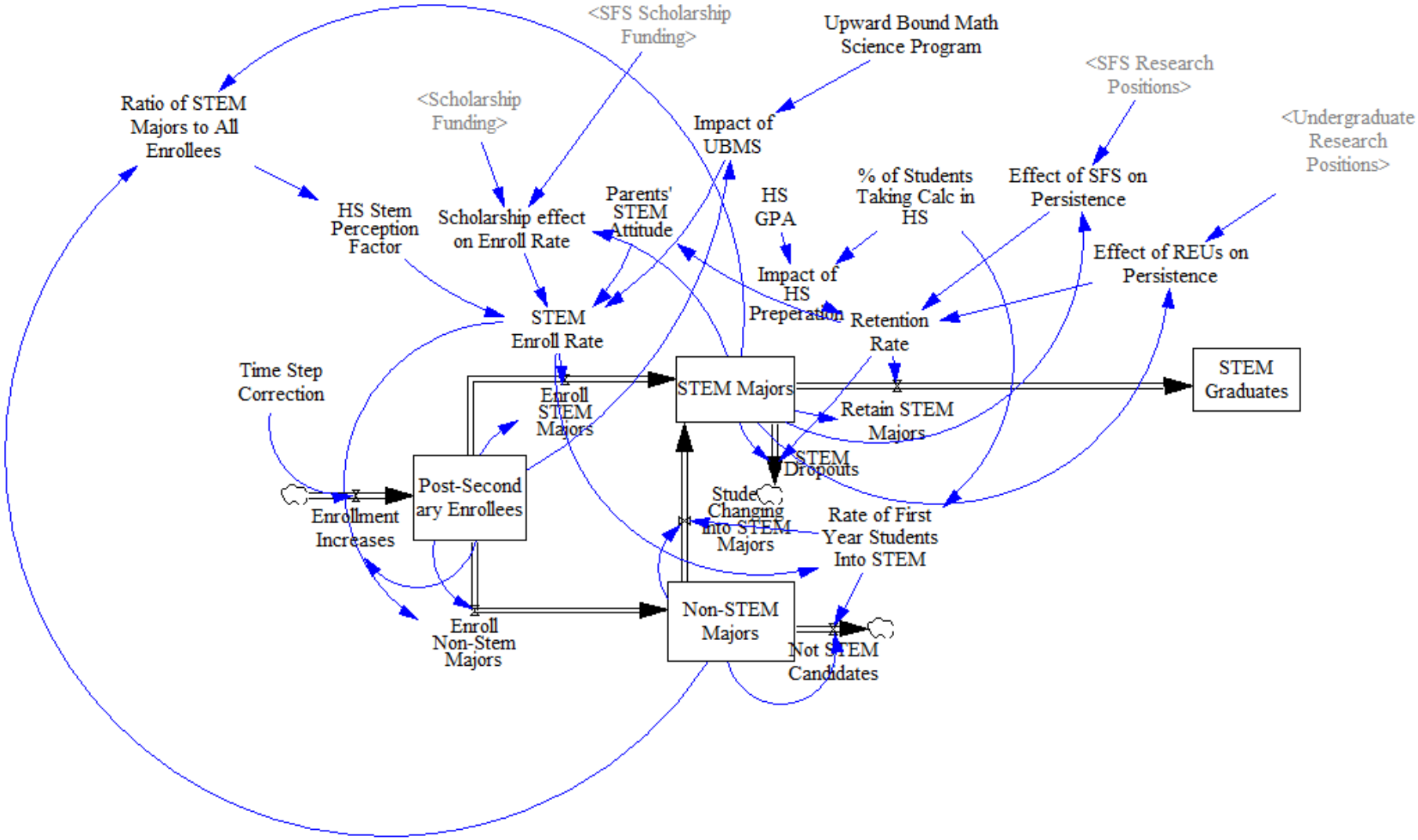
System Dynamics Model



System Dynamics Model



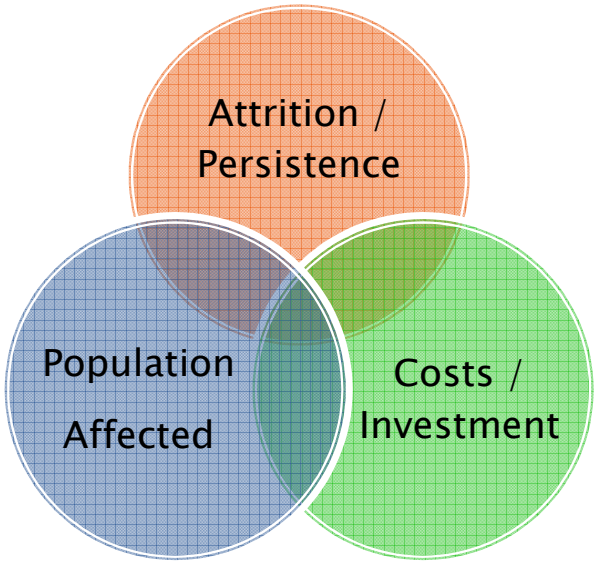
System Dynamics Model



Parameter Formulation

- Parameters which affect Enrollment, Retention or Switching Rates
- General parameter format:

Percentage of Population Affected * Rate effect as a function of Investment



Model Data Needs

Parameter Formulation

Enrollment Rate Effect due to STEM Scholarships:

Fiscal Year 2010 Federal Budget

Determined from Program Descriptions

Values from Student Aid Study[1]

$$\frac{\Sigma \text{ STEM Scholarship Funding}}{\text{STEM Scholarship Students}_i} * \frac{\text{STEM Scholarship Students}_i}{\text{STEM Majors}} * \frac{\Delta \text{ Enrollment Rate}}{\Delta \text{ Scholarship Size}}$$

Determined from Program Descriptions

Calculated by the SD Model

1. (Bettinger, 2004), How Financial Aid Affects Persistence
2. i=varies for each scholarship

Programs Studied: 18 Programs >$750Million in FY10 funding

Scholarships for Service

- Hollings Undergraduate Scholarship Program
- Stokes Educational Scholarship Program
- Aeronautics Scholarship
- Federal Cyber Service

Research Experiences for Undergraduates (REU)

- Awards to Stimulate & Support Undergraduate Research Experiences (ASSURE)
- Naval Research Enterprise Program (NREIP)
- Science Undergraduate Laboratory Internships (SULI)
- Undergraduate Student Research Project (USRP)
- Summer Undergraduate Research Fellowship Program (SURF)

STEM Scholarship Programs

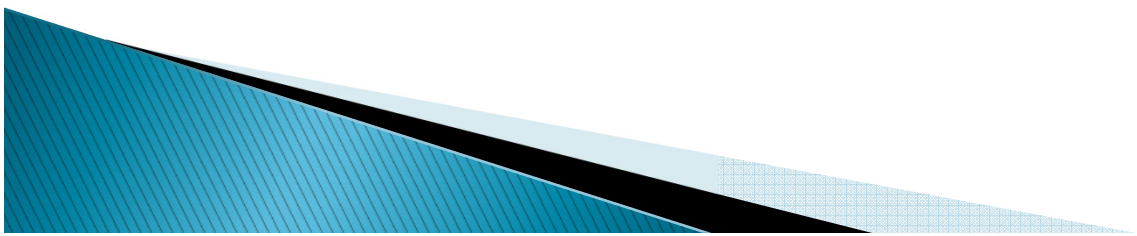
- DoD SMART Scholarships
- Dept of ED SMART Scholarships
- Undergraduate Scholarship Program for Individuals from Disadvantaged Backgrounds
- NSF STEM Scholarships (S-STEM)

Other STEM Education Programs

- Upward Bound Math Science Program
- Global Climate Change Education
- Motivating Undergraduates in Science & Technology
- University Transportation Centers Program

Study Limitations

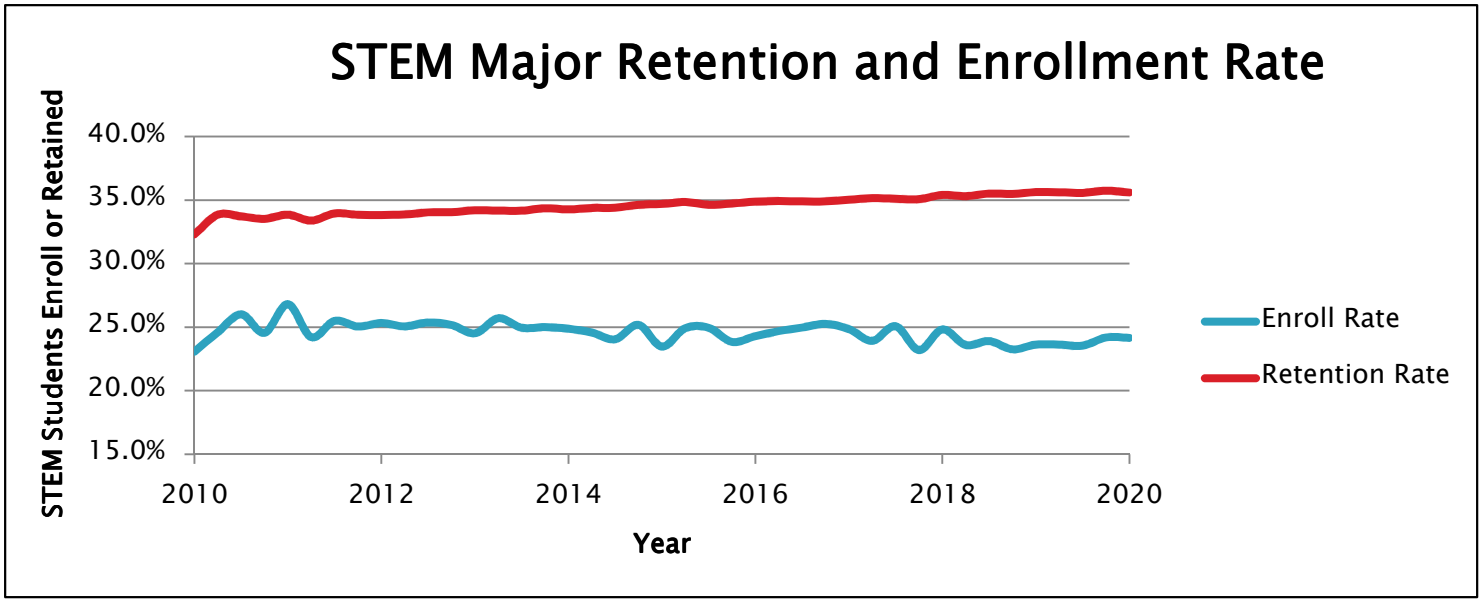
- Lack of data
  - Project scope does not include data collection
  - Program effectiveness and performance
  - Factors affecting attrition and persistence
  - Publically available data only



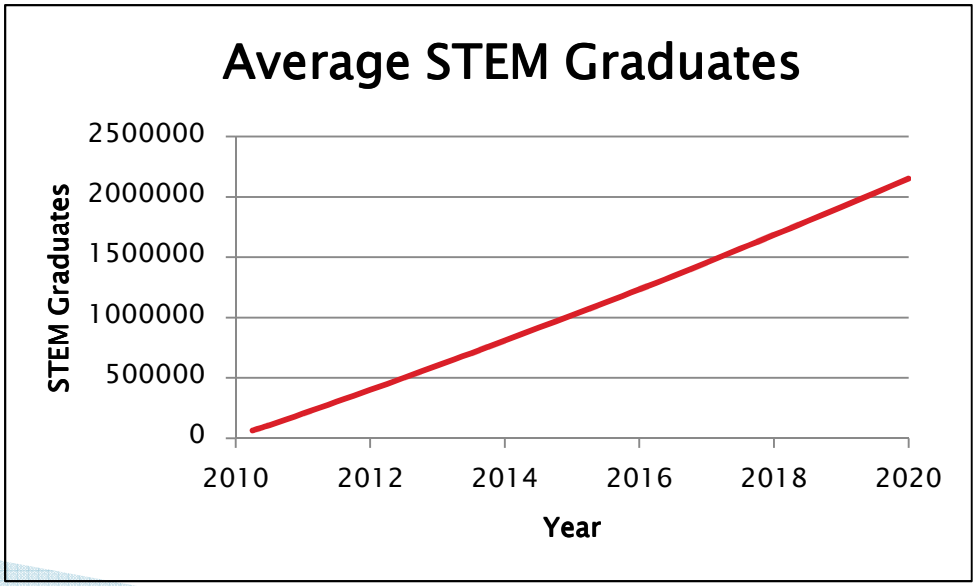
Model Assumptions

- Complicating factors intentionally omitted
  - STEM Teacher Pipeline
  - Demographics
  - Cultural aspects
  - K-12 Experiences
  - Non-governmental STEM initiatives
- Stability of STEM 2010 program inventory
- **Constant factor effects during simulation***
- Combined data across recent fiscal years to build model
- Not considering seasonality of enrollment

Base Case Output



- 30 Runs per model variant
- All random variables independent
- Quarter year time steps

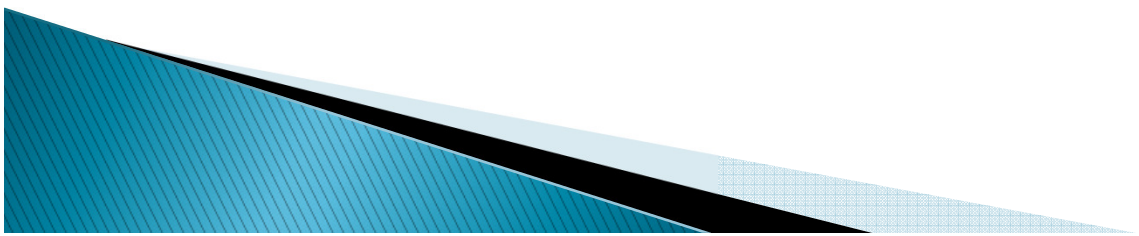


Hypotheses

One of these factors is the most important to STEM Persistence Rates:

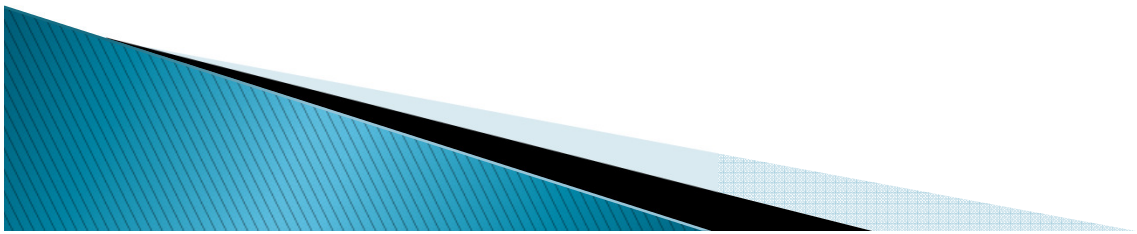
1. Student Scholarship Funding
2. Research Experience for Undergraduates (REU)

- Number of Students Receiving Scholarships
  - Size of scholarship affects student persistence



Analysis Cases

- Return On Investment (ROI)
  - Dollars Invested per Students Persisting
    - STEM Scholarships Investment
    - REU Expansion
- Assumption Testing
  - How does the **size** of the scholarship affect **Student Persistence**?
    - Case 1: Persistence increases with scholarship size
    - Case 2: Persistence depends only on the number of students getting scholarships



Return on Investment

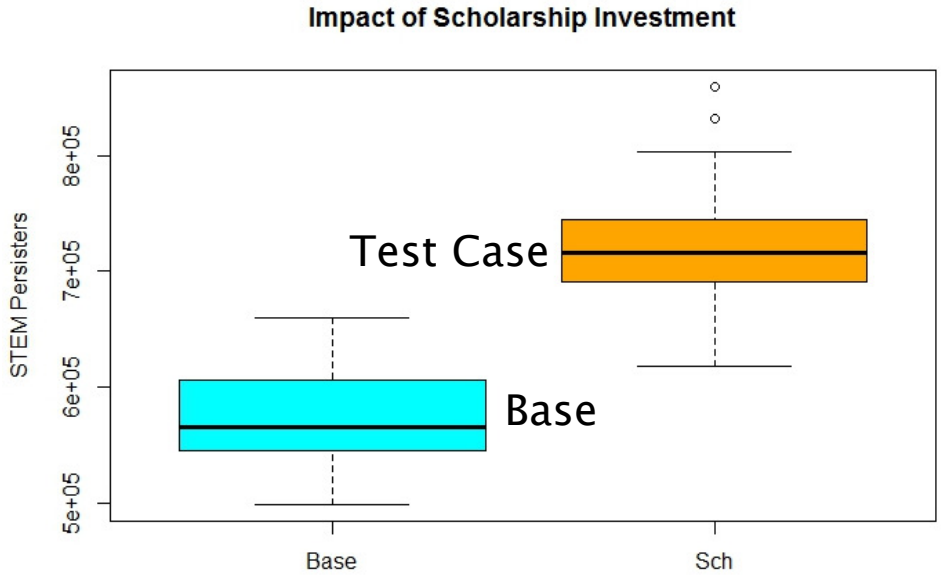
- If funding is **increased** in 2015 by a fixed amount, what is this effect?
- Compare Scholarship and REU cases to the Base Case using the Tukey Test
  - Obtained 95% CI on the mean of the difference

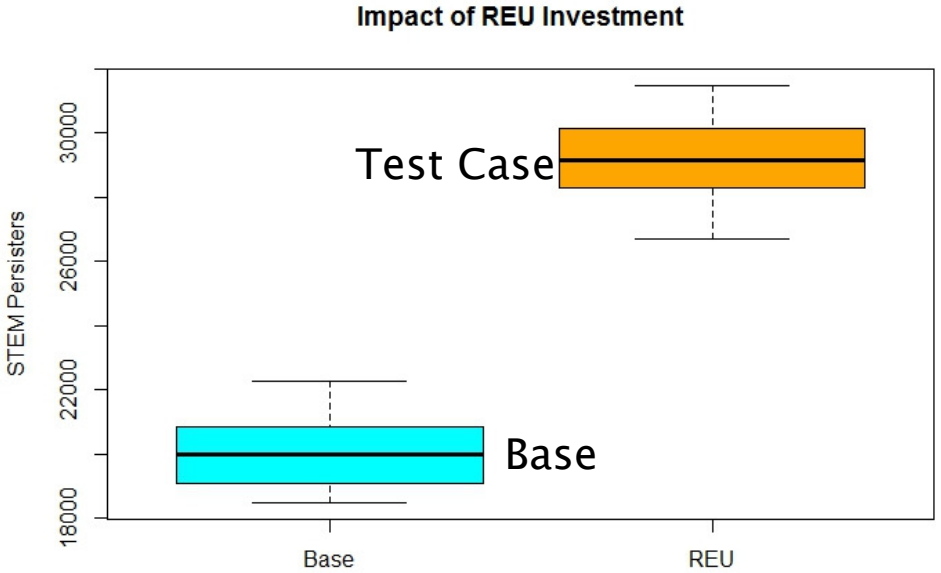
$$ROI = \frac{\#\ Persisters\ in\ variant\ model - \ \#Persisters\ in\ base\ model}{Funding\ Difference}$$

ROI – Results

	Dollars per Student		
	Mean	L Bound	U Bound
REU	$ 4,938.74	$ 4,648.76	$ 5,267.30 *
Scholarships	$ 2,742.70	$ 2,355.25	$ 3,282.74 *

* p-value < 0.001





Levene's Test	
Comparison	**p-value**
REU - Base	0.2613
Scholarship - Base	0.556

Assumption Testing

- How does the size of the scholarship affect Student Persistence?
- Alter model to use a fixed persistence rate for each student receiving a STEM scholarship

Fixed Persistence Rate[3]

$$\frac{\#Scholarship\ Students}{Total\ \#STEM\ Students} * 0.16$$

Variable Persistence Rate[4]

$$\frac{\sum Scholarship\ Funding}{Total\ \#STEM\ Students} * \frac{Normal(3.3\%, 0.16\%)}{\$1000}$$

3. (Noel-Levitz, 2011), Targeting Financial Aid for Improved Retention Outcomes
4. (Bettinger, 2004), How Financial Aid Affects Persistence

Assumption Testing Results

Tukey's Test

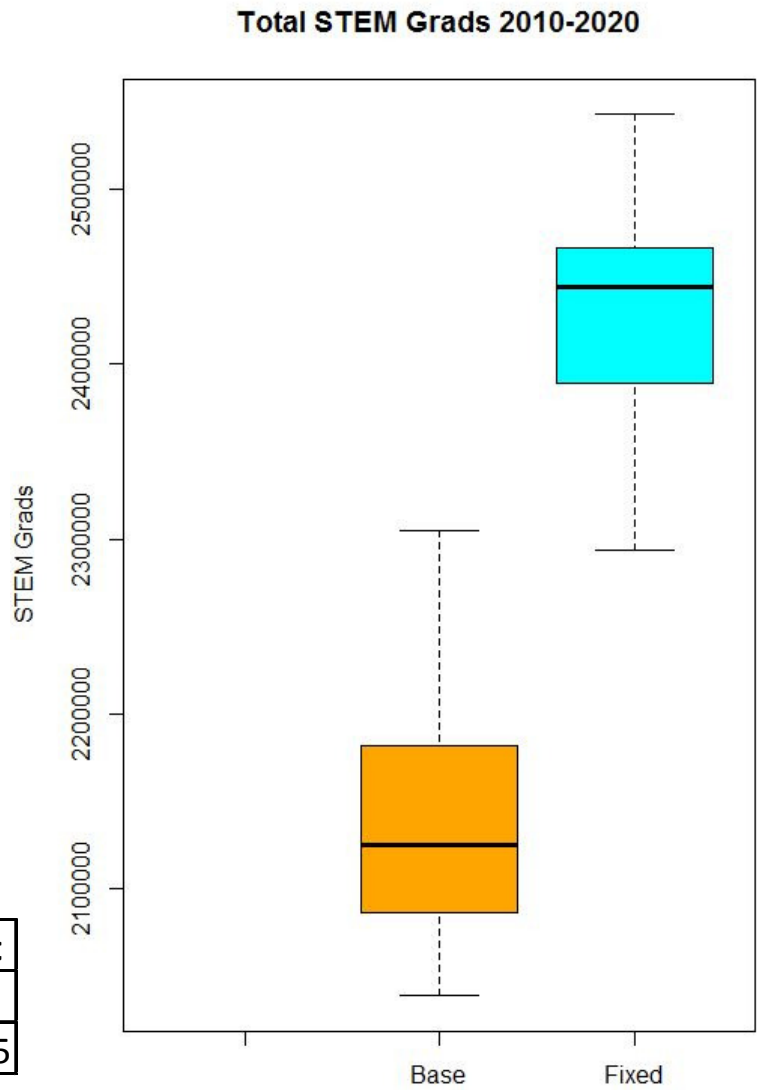
- Generated a 95% CI on the mean of the difference between Total STEM Graduates 2010 – 2020

	Total STEM Graduates (2010-2020)		
	Mean	L Bound	U Bound
Fixed - Variable	293983	260295	327670

* p-value < 0.001

- Current scholarship situation favors fixed persistence rate model

Levene's Test
p-value
0.2385

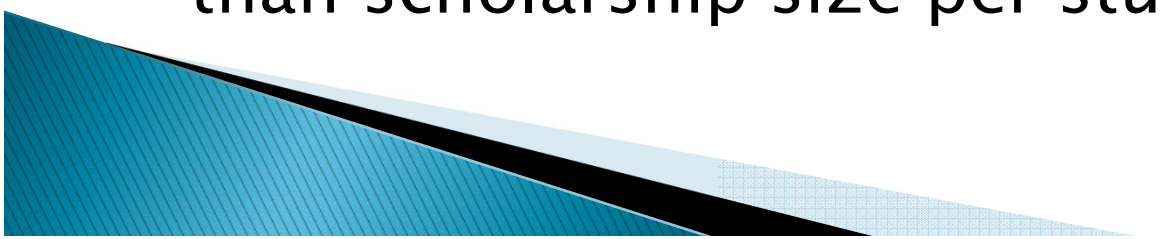


Performance Management & Data Conclusions

- Agencies should base STEM program goals on intersection of agency goals with STEM goals
- Gov't needs to report student level outcomes to facilitate federal level decision making
- Decouple STEM funding from non-STEM funding in broad-based programs

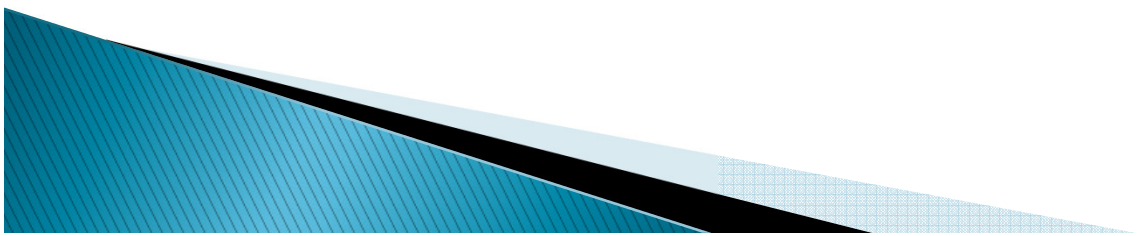
Modeling and Analysis Conclusions

- Scholarships provide a higher ROI than REUs
  - ~$2.7B in additional STEM Scholarship funding would meet STEM Cross-Agency Goal (1,000,000 more students in 10 Years)
- Proportion of STEM students receiving scholarships has a greater affect on persistence than scholarship size per student



Further Research

- Areas of potential model expansion:
  - Incorporate more of the STEM pipeline
  - STEM Infrastructure Investments
  - STEM Curriculum Enhancements
- What is the effect of private sector STEM outreach programs?
- Investigate social factors relating to STEM attrition.



Questions?

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    - Tyndall Traversa
    - Rob Brown
  - Dr. Laskey