Growth, Distance to Frontier and Composition of Human Capital

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Presentation is based on...

- Vandenbussche, Aghion, Meghir (2006), “Growth, distance to frontier and composition of human capital”, *Journal of Economic Growth*, 11, 97-127.

- Aghion, Boustan, Hoxby, Vandenbussche (2006), “Exploiting states’ mistakes to identify the causal effect of higher education on growth”, mimeo Harvard.

These papers do not necessarily reflect the views of the IMF

Two effects of education on growth

- *Accumulation* of human capital matters in an "augmented" neoclassical production function

→empirical evidence: Cohen-Soto (2001), De la Fuente-Domenech (2006), Krueger-Lindahl (2001)

- *Level* of human capital matters because it contributes to technological progress

→typical measure is average number of years of education

→empirical evidence (correlation): Barro (1998)

→no evidence in developed economies: Krueger and Lindahl (2001)

→we focus on this apparent puzzle

- We take inspiration from the literature on "appropriate institutions", in particular Acemoglu, Aghion and Zilibotti (2006)

Our approach (theory)

We explore the link between productivity growth and education in developed economies, acknowledging that:

- Technological progress is dual:
  - imitation / adoption of technologies
  - innovation

- Human Capital is heterogeneous:
  Low skill human capital is typically better suited to adoption than to innovation

→ Need to take distance to technological frontier into account *and* disaggregate human capital

→This approach can potentially explain the Krueger and Lindahl puzzle by highlighting the importance of the composition, as opposed to the level, of education

Summary of theoretical analysis

- Stylized endogenous growth model where skilled and unskilled labor are allocated to tasks of production, imitation and innovation
- Optimal allocation depends on the distance to the technological frontier
- Reallocation process from imitation to innovation activities generates complementarity between skilled human capital and proximity to the frontier (Rybczynski effect).

→Main result: Growth-enhancing impact of skilled human capital increases with level of development

- When migration to the frontier is allowed, this complementarity becomes stronger

Empirical analysis: the identification problem

- Education investments are endogenous
- Bils and Klenow (2000) critique: reverse causality.
- Or, suppose
  - some areas just have higher productivity growth;
  - they grow faster, end up richer and closer to the frontier;
  - they may spend more on high skill education as a luxury of sorts

⇨ Again, correlation but not causation

Preview of Empirical Results

- Vandenbussche, Aghion, Meghir (2006) [VAM]: focus on attainment
  - 19 OECD countries observed every five years between 1960 and 2000
  - Education data: Barro-Lee (2000) and De la Fuente-Domenech (2006)
  - Difficult to find credibly exogenous variation in education investments. We used 10-year lagged public education expenditures (Unesco, 1999) as econometric instruments

- Aghion, Boustan, Hoxby, Vandenbussche (2006) [ABHV]: focus on spending and attainment
  - 26 cohorts (born 1947-1972) in 48 U.S. states
  - Strengths:
    - much more credible instruments available
    - data quality/comparability
    - finer data classification of types of higher education
  - Model integrates migration

- Empirical results support our theoretical prediction

→ The closer (further) is a state to the technological frontier, the more growth-enhancing it is to invest in high-skill (low-skill) education.

VAM – Fractions (tertiary education)

TABLE 1 - VAM
TFP GROWTH EQUATION (FRACTIONS)

	D-D	Barro-Lee
Proximity	-0.31	-0.32
	(.063)***	(.055)***
Fraction	0.427	0.331
	(.146)***	(.12)**
Proximity*Fraction	1.06	1.27
	(.28)***	(.34)***
Country dummies	Groups	Groups
Proximity threshold	-0.403	-0.261
	(.052)	(.057)
Number of observations	118	122

Note : standard errors in parentheses. Time dummies not reported. Countries are grouped in the following way:
Group 1: Belgium, France, Italy, Netherlands;
Group2: The four Scandinavian countries, Austria, UK, Switzerland; Group3: Canada, US;
Group 4: Australia, New Zealand; Group 5: Portugal, Spain; Group 6: Greece; Group 7: Ireland.
Proximity is the log ratio of a country's tfp to the technological frontier's tfp (hence it is a negative number).
Proximity threshold indicates the value of Proximity above which Fraction is growth-enhancing.
One, two and three * indicate significance at the 10, 5 and 1% level respectively.

VAM – Years of education

TABLE 2 - VAM
TFP GROWTH EQUATION (YEARS)

	D-D	Barro -Lee
Proximity	-0.14	-0.225
	(.12)	(12)*
YearsPS	-0.0086	-0.004
	(.007)	(.015)
YearsT	0.19	0.183
	(.08)**	(.11)
Proximity*YearsPS	-0.022	-0.026
	(.019)	(.03)
Proximity*YearsT	0.53	0.61
	(.2)**	(.28)**
Country dummies	Groups	Groups
Proximity threshold	-0.358	-0.300
	(.16)	(.05)
Number of observations	118	122

Note : standard errors in parentheses. Time dummies not reported. Countries are grouped in the following way:
Group 1: Belgium, France, Italy, Netherlands;
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VAM – Quantitative effects

- Effects at the frontier
  - An increase by 10 percentage points of the fraction of people with some tertiary education would raise tfp growth by 0.6 to 0.8 percentage points
  - An increase by 0.5 year of the average tertiary education attainment would raise tfp growth by 2 percentage points
- Effects at 0.7 of frontier are negligible

- *Remark*: First stage regressions are supportive of a positive effect of public spending on tertiary education to tertiary education attainment; less so for primary/secondary education.

ABHV - Data

- Panel: 1947 to 1972 birth cohorts, 48 states
- Add up all education spending associated with a cohort's education opportunities
  - e.g. how much was spent per cohort member on four-year college type education while cohort was age 18-21?
  - how much was spent per cohort member on graduate education while cohort was age 22-25?
- Also use an attainment-based measure of education investment (retrospective from Census)
- Measure labor productivity growth during 10 years following entry of cohort on labor market

ABHV - Logic of our instruments

- Individual appointments to key political committees generate state "mistakes" (arbitrary variation) in education investments

- Individual politician needs to pay back his constituents.
- His interest not necessarily representative of committee's general mandate or contemporary partisan politics.
- His position only gives him ability to deliver in specific forms (e.g. research not primary education).
- Ends up making education investments based on forms of pork he can deliver.

Example: federal appropriations committees and investment in research education

- State gets member on House or Senate appropriations committee
  - Appointment reflects not just contemporary partisan politics…
  - but complex interaction of states' political histories
- Appropriations committees can earmark research funds for specific universities (without regard to scientific merit)
  - Important means of channeling 'pork' to home state
  - Cannot channel funds to secondary or 'lowbrow' postsecondary education even if that is what the home state would prefer

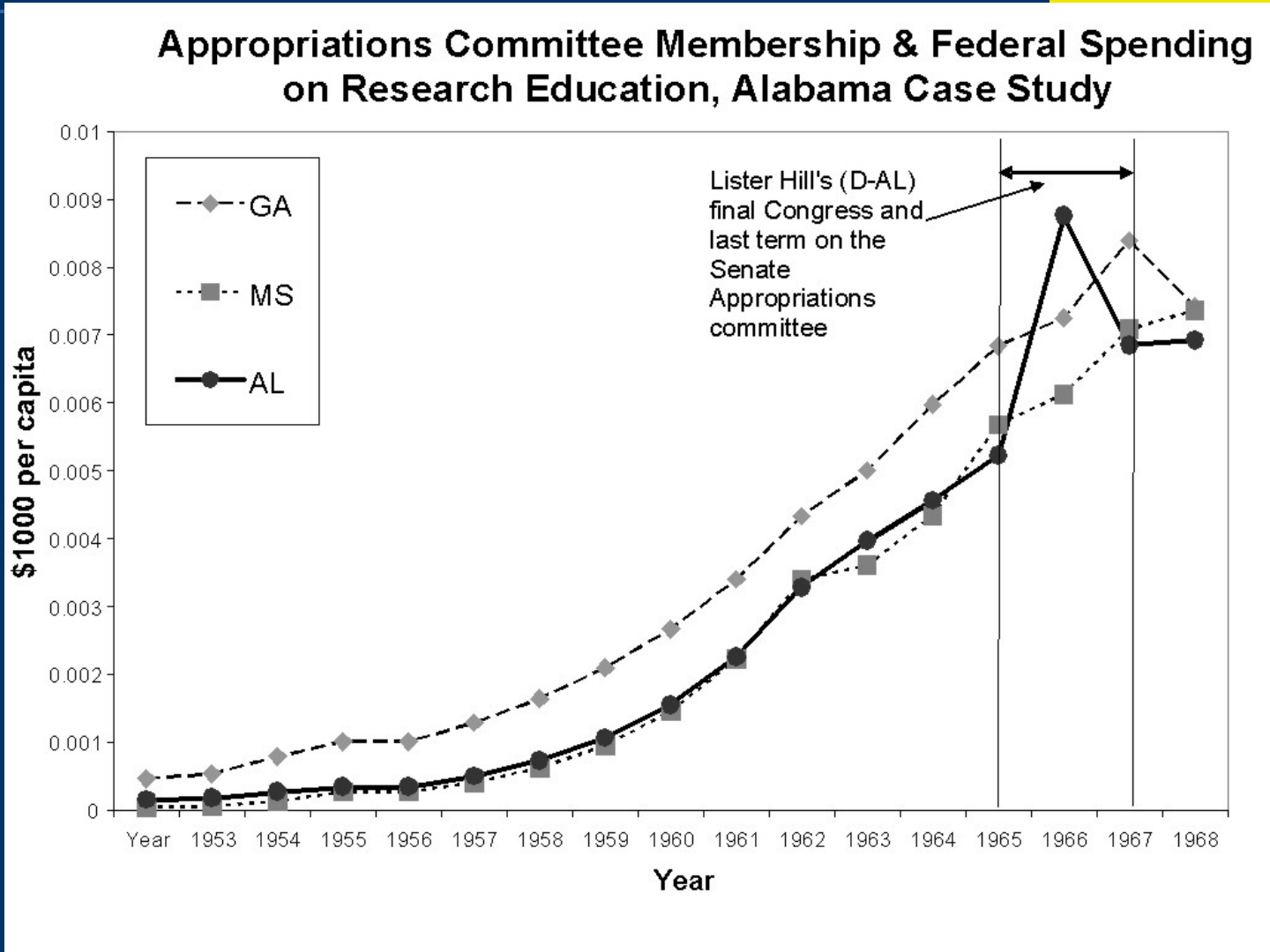
Instruments for research education spending: appointments of state representatives to federal appropriations committees

- We can control for contemporary partisan politics in state since they are not much correlated
- Because the timing of appointments is arbitrary, we can control for
  - State effects
  - Cohort (year) effects
  - Census division time trends
- Identification thus from within-state, within-cohort, within-typical-trend-for-region correlation between political appointments and education spending

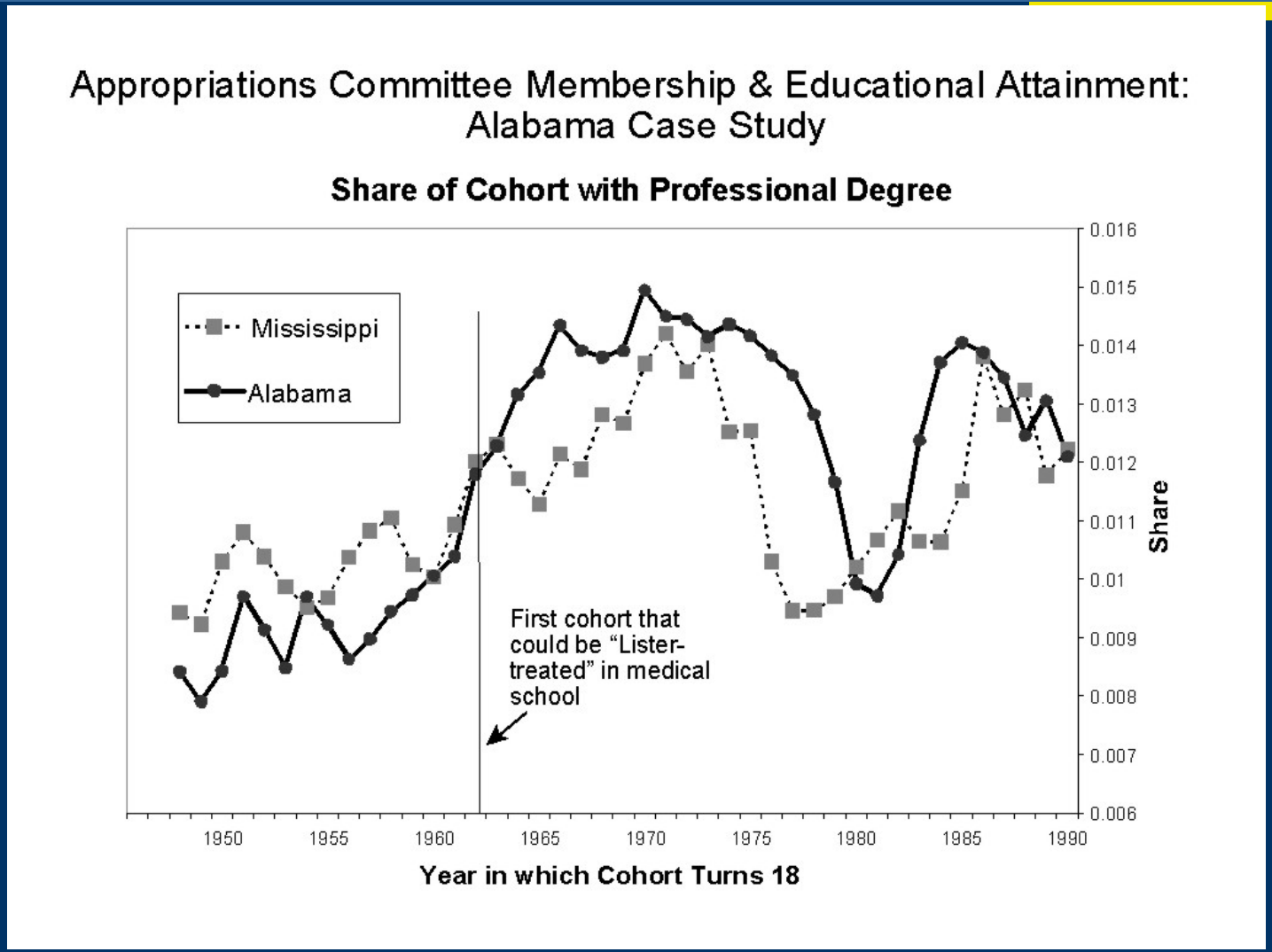
Instruments for 4-year college spending: appointments of district representatives to state committee chairmanships interacted with constituents' self-interest

- Key idea: If a district contains a 4-year college, its representative will favor 4-year colleges when he becomes a chairman, even if he and his constituents are generally anti-spending and even anti-education-spending
- We control for contemporary partisan politics and demographics in state and in the representative's own district
- Identification thus from within-state, within-cohort, within-typical-trend-for-region variation in its chairmen's "self-interest" in college spending
- Instruments for 2-year college spending are analogous

Case study: Alabama (Lister Hill)



Case study: Alabama (Lister Hill)



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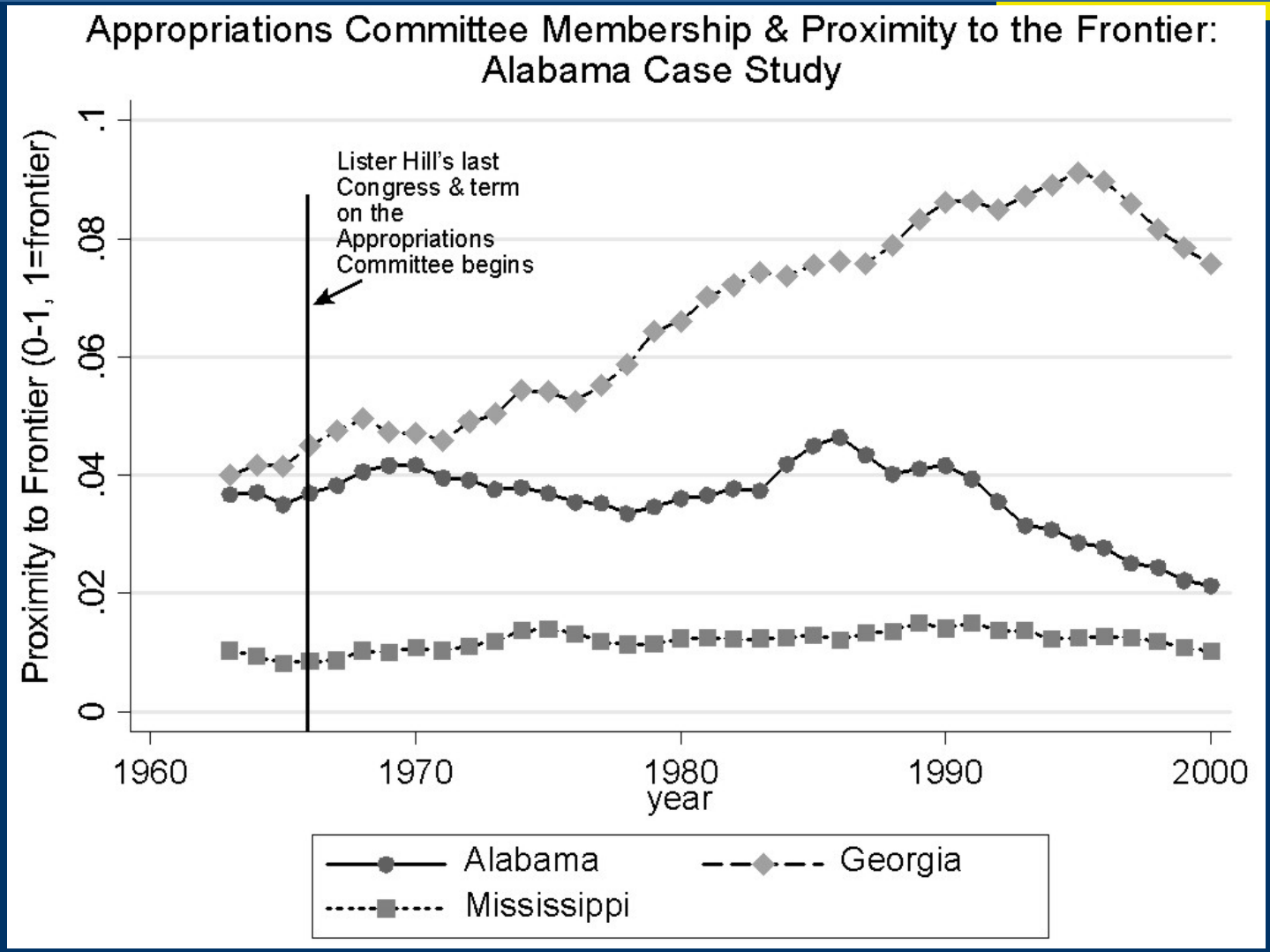

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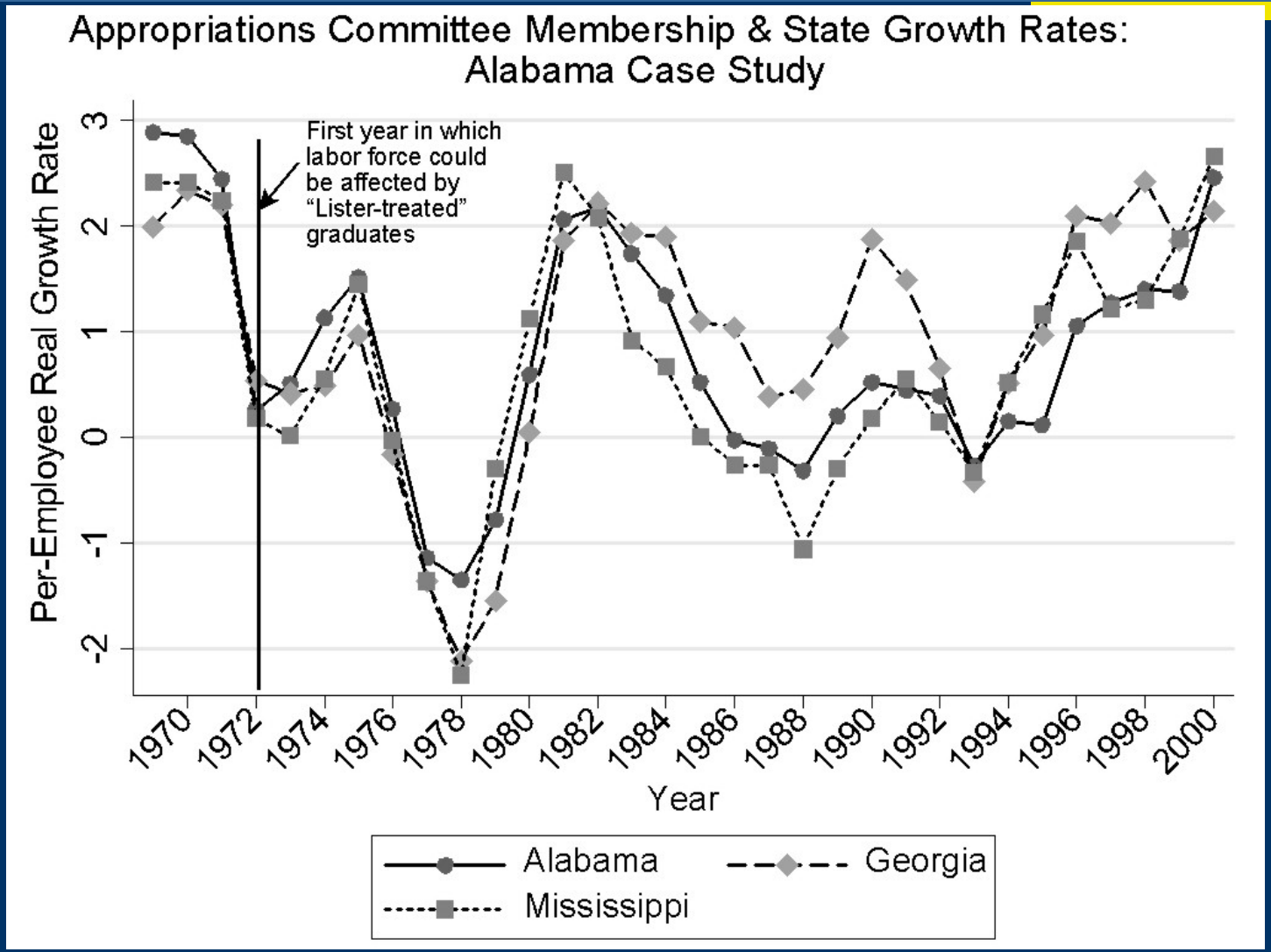


First-stage for research-type spending

Dep var: Exp on research univ per person in cohort		
	Coefficient	Robust S.E.
Excluded instruments:		
Members on House Appropriations Committee	597.2	173.3
Members on Senate Appropriations Committee	419.5	113.4
Other covariates (also in 2nd-stage eqn)		
% vote by party, last Presidential election	Yes	
% vote by party, last Congressional election	Yes	
State indicator variables	Yes	
Cohort indicator variables	Yes	
Census division linear time trends	Yes	
F-statistic, excluded instruments	10.32	

First-stage for 4-year college spending

Dep var: Exp on 4-yr college per person in cohort		
	Coefficient	Robust S.E.
Excluded instruments:		
# 4-yr colleges in own constituency (M of students)	133.7	22.8
# 2-yr colleges in own constituency (M of students)	-28.5	5.3
Other covariates (also in 2nd-stage eqn)		
% of employment by industry, own constituency	Yes	
% in each party, state's upper house; lower house	Yes	
State indicator variables	Yes	
Cohort indicator variables	Yes	
Census division linear time trends	Yes	
F-statistic, excluded instruments	10.03	

First-stage for 2-year college spending

Dep var: Exp on 2-yr college per person in cohort		
	Coefficient	Robust S.E.
Excluded instruments:		
# 4-yr colleges in own constituency (M of students)	23.4	5.5
# 2-yr colleges in own constituency (M of students)	134.8	22.6
Other covariates (also in 2nd-stage eqn)		
% of employment by industry, own constituency	Yes	
% in each party, state's upper house; lower house	Yes	
State indicator variables	Yes	
Cohort indicator variables	Yes	
Census division linear time trends	Yes	
F-statistic, excluded instruments	10.12	

Note that first-stage relationships from instruments to educational attainment of a state's *residents*…

- do not work for research-type education at all ('highbrow' types fully arbitrage through migration)
- work only so-so for four-year and two-year type of college education

ABHV results: education investment measured by spending

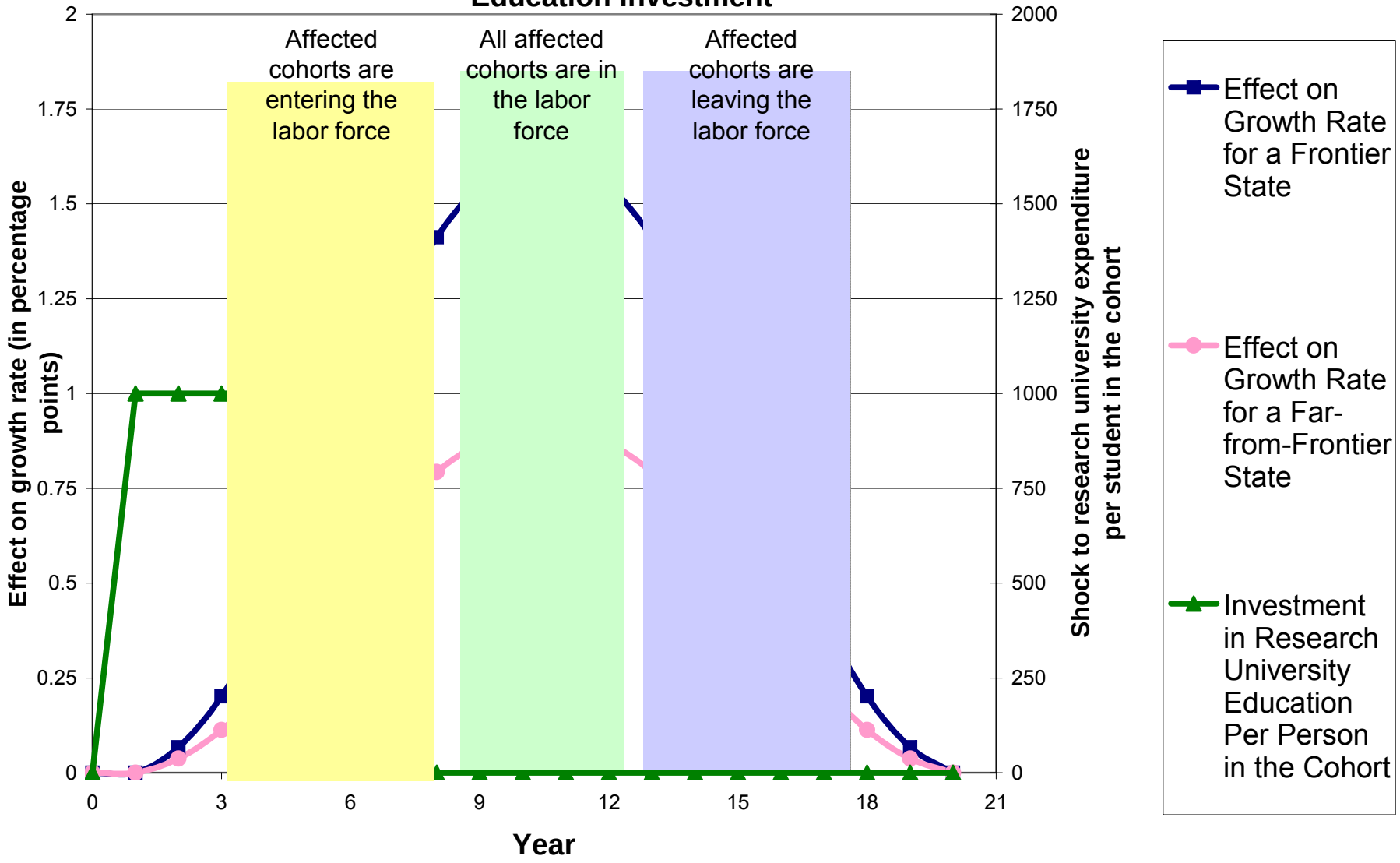
Dependent variable: Annual rate of growth, gross state product per employee in $2004

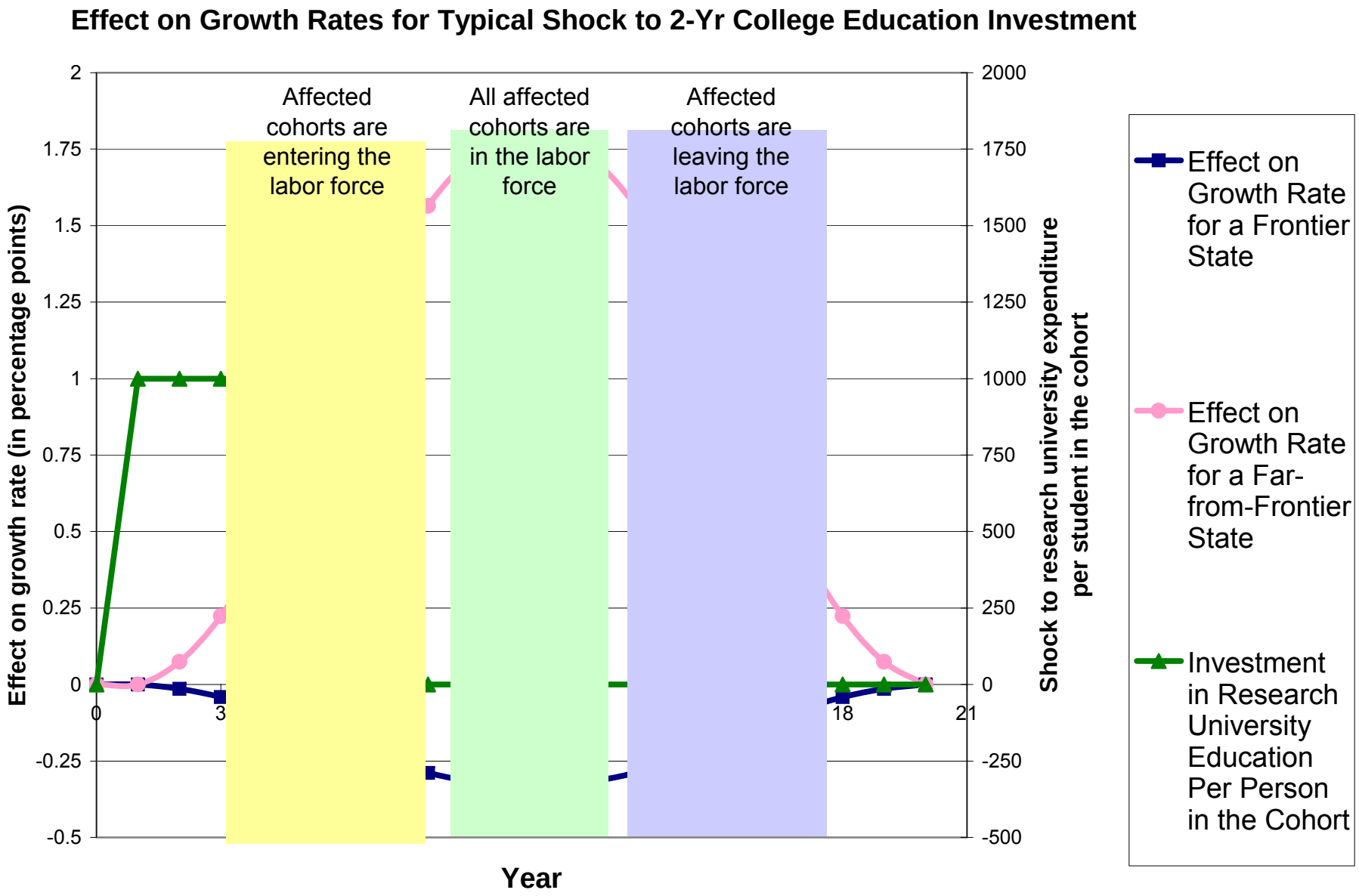
	Instruments for Education Expenditures Variables & Proximity	
	Coefficient	Robust Standard Error
Expenditure (thousands) on research universities per person in cohort	0.034	0.095
Expenditure (thousands) on 4-year colleges per person in cohort	**-0.283**	0.152
Expenditure (thousands) on 2-year colleges per person in cohort	**0.65**	0.136
Expenditure (thousands) on elem/sec. public education per person in cohort	-0.105	0.1
Proximity *Expenditure (thousands) on research universities per person in cohort	**0.234**	0.117
Proximity *Expenditure (thousands) on 4-year colleges per person in cohort	**0.34**	0.155
Proximity *Expenditure (thousands) on 2-year colleges per person in cohort	**-0.705**	0.151
Proximity *Expenditure (thousands) on elem/sec. public educ. per person in cohort	**-0.1**	0.02
Proximity to frontier (0-1 index, based on average revenue product of labor)	**-12.24**	3.15
All political variables included in a first-stage equation	yes	
State indicator variables	yes	
Cohort indicator variables	yes	
Census Division linear time trends	yes	

ABHV results: education investment measured by spending

Effects for far-from-frontier states (0.5 of frontier)	
Expenditure (M) on research-type ed per person in cohort	0.152
Expenditure (M) on 4-yr college ed per person in cohort	-0.113
Expenditure (M) on 2-yr college ed per person in cohort	0.298
Effects for at-the-frontier states	
Expenditure (M) on research-type ed per person in cohort	0.269
Expenditure (M) on 4-yr college ed per person in cohort	0.057
Expenditure (M) on 2-yr college ed per person in cohort	-0.055

Figure 15: Effect on Growth Rates for Typical Shock to Research-Type Education Investment




Effect on Growth Rates for Typical Shock to 2-Yr College Education Investment
Affected cohorts are entering the labor force
All affected cohorts are in the labor force
Affected cohorts are leaving the labor force
Effect on growth rate (in percentage points)
Shock to research university expenditure per student in the cohort
Year
2
1.75
1.5
1.25
1
0.75
0.5
0.25
0
-0.25
-0.5
2000
1750
1500
1250
1000
750
500
250
0
-250
-500
0
3
18
21
Effect on Growth Rate for a Frontier State
Effect on Growth Rate for a Far-from-Frontier State
Investment in Research University Education Per Person in the Cohort

ABHV results: education investment measured by attainment

Dependent variable: Annual rate of growth, gross state product per employee in $2004		
	Instruments for Education Expenditures Variables & Proximity	
	Coefficient	Robust Standard Error
Research degree holders in cohort per 10,000 in the labor force	**-1.116**	0.172
Baccalaureate degree holders in cohort per 10,000 in the labor force	**0.172**	0.044
Persons in cohort with some college per 10,000 in the labor force	0.021	0.017
Proximity *Research degree holders in cohort per 10,000 in the labor force	**1.541**	0.193
Proximity *Baccalaureate degree holders in cohort per 10,000 in the labor force	**-0.214**	0.043
Proximity *Persons in cohort with some college per 10,000 in the labor force	-0.022	0.019
Proximity to frontier (0-1 index, based on average revenue product of labor)	-10.76	3.49
All political variables included in a first-stage equation	yes	
State indicator variables	yes	
Cohort indicator variables	yes	
Census Division linear time trends	yes	

ABHV results: education investment measured by attainment

Effects for far-from-frontier states (0.5 of frontier)	
Research degree holders in cohort per 10,000 in labor force	-0.346
Baccalaureate degree holders in cohort per 10,000 in labor force	0.065
Persons in cohort with some college per 10,000 in labor force	0.010
Effects for at-the-frontier states	
Research degree holders in cohort per 10,000 in labor force	0.425
Baccalaureate degree holders in cohort per 10,000 in labor force	-0.042
Persons in cohort with some college per 10,000 in labor force	-0.001

Specification test: control for capital investment

	Basic spec.	Control for capital investmt & its interaction w/ proximity
Effects for far-from-frontier states (0.5 of frontier)		
Exp.(M) on research-type ed per person in cohort	0.152	0.162
Exp. (M) on 4-yr college ed per person in cohort	-0.113	-0.093
Exp.(M) on 2-yr college ed per person in cohort	0.298	0.193
Effects for at-the-frontier states		
Exp.(M) on research-type ed per person in cohort	0.269	0.247
Exp.(M) on 4-yr college ed per person in cohort	0.057	0.132
Exp.(M) on 2-yr college ed per person in cohort	-0.055	-0.142

Specification test: control for all other federal spending on states

	Basic spec.	Control for federal exp & its interaction w/ proximity
Effects for far-from-frontier states (0.5 of frontier)		
Exp.(M) on research-type ed per person in cohort	0.152	0.178
Exp. (M) on 4-yr college ed per person in cohort	-0.113	-0.081
Exp.(M) on 2-yr college ed per person in cohort	0.298	0.186
Effects for at-the-frontier states		
Exp.(M) on research-type ed per person in cohort	0.269	0.237
Exp.(M) on 4-yr college ed per person in cohort	0.057	0.131
Exp.(M) on 2-yr college ed per person in cohort	-0.055	-0.110

Conclusions (1)

- From cross-OECD analysis, we find that tertiary education attainment enhances productivity growth more significantly for countries that are closer to the technological frontier. We do not find robust evidence regarding the effect of primary/secondary education.
- From cross-US states analysis, we find that investments in 'highbrow' education are substantially more growth-enhancing for states that are closer to the technological frontier… and that conversely, investments in 'lowbrow' education are more growth-enhancing for states that are far below the technological frontier.
- Across US states, the analysis shows that:
  - $1000/person in a cohort on research-type education in an at-the-frontier state raises the growth rate by 0.27 percentage points, but raises it only 0.15 percentage points for a far-from frontier state
  - Split between 'highbrow' and 'lowbrow' education appears to be between higher and lower postsecondary education *for the U.S.*

Conclusions (2)

- Our analysis (both theoretical and empirical) could be enriched in the future by including in particular:
  - Intertemporal / dynamic aspects
  - International / interregional specialization and trade
  - Migration of low-skill workers

Post-Scriptum: Recent IMF work on efficiency of public spending

- G7 (2007; education and health; unpublished)
- Czech Republic (2007; education, health and social protection)
- Slovenia (2007; education, health and social protection)
- Latin America (2007; infrastructure)