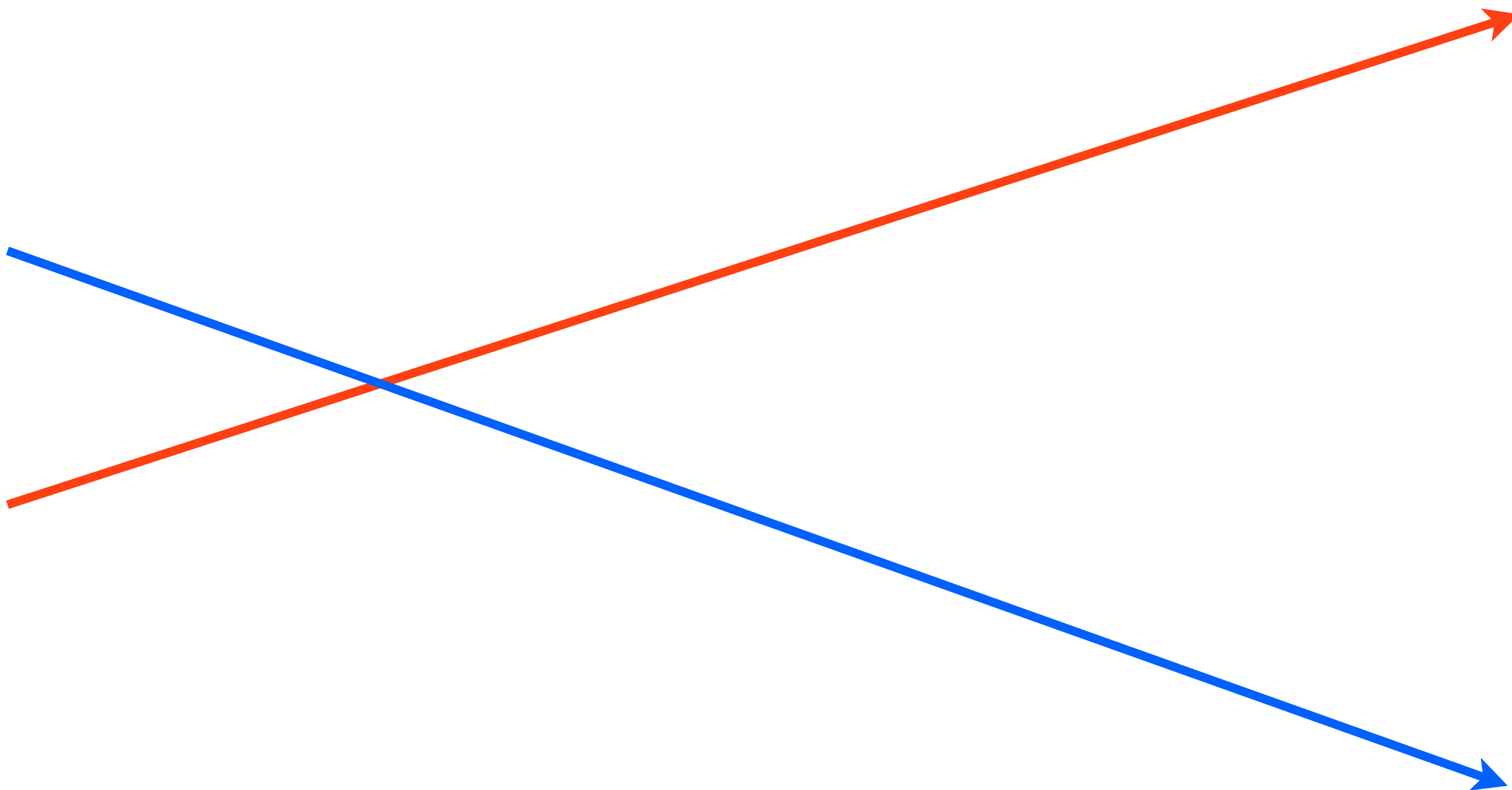


# The Education / Information Chasm

EduComm  
15 June 2011  
Orlando

Bret Swanson  
[entropyeconomics.com](http://entropyeconomics.com) | [bretswanson.com](http://bretswanson.com)



# Schema

Children try to manipulate every screen of any type as if it were a multi-touch display, like the iPhone.

TVs, computers, laptops, even magazines.





# Schema

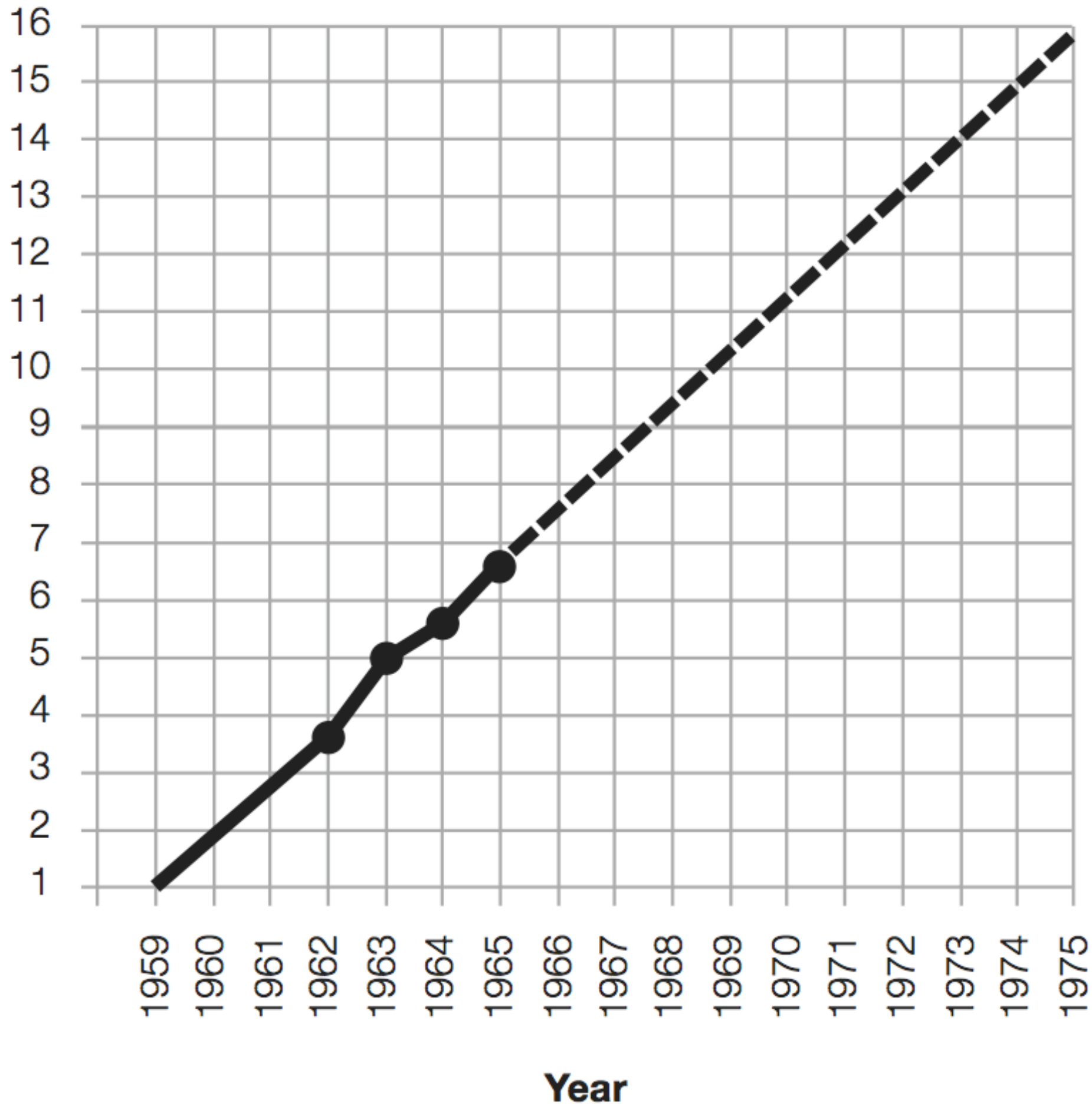


Children try to manipulate every screen of any type as if it were a multi-touch display, like the iPhone.

TVs, computers, laptops, even magazines.

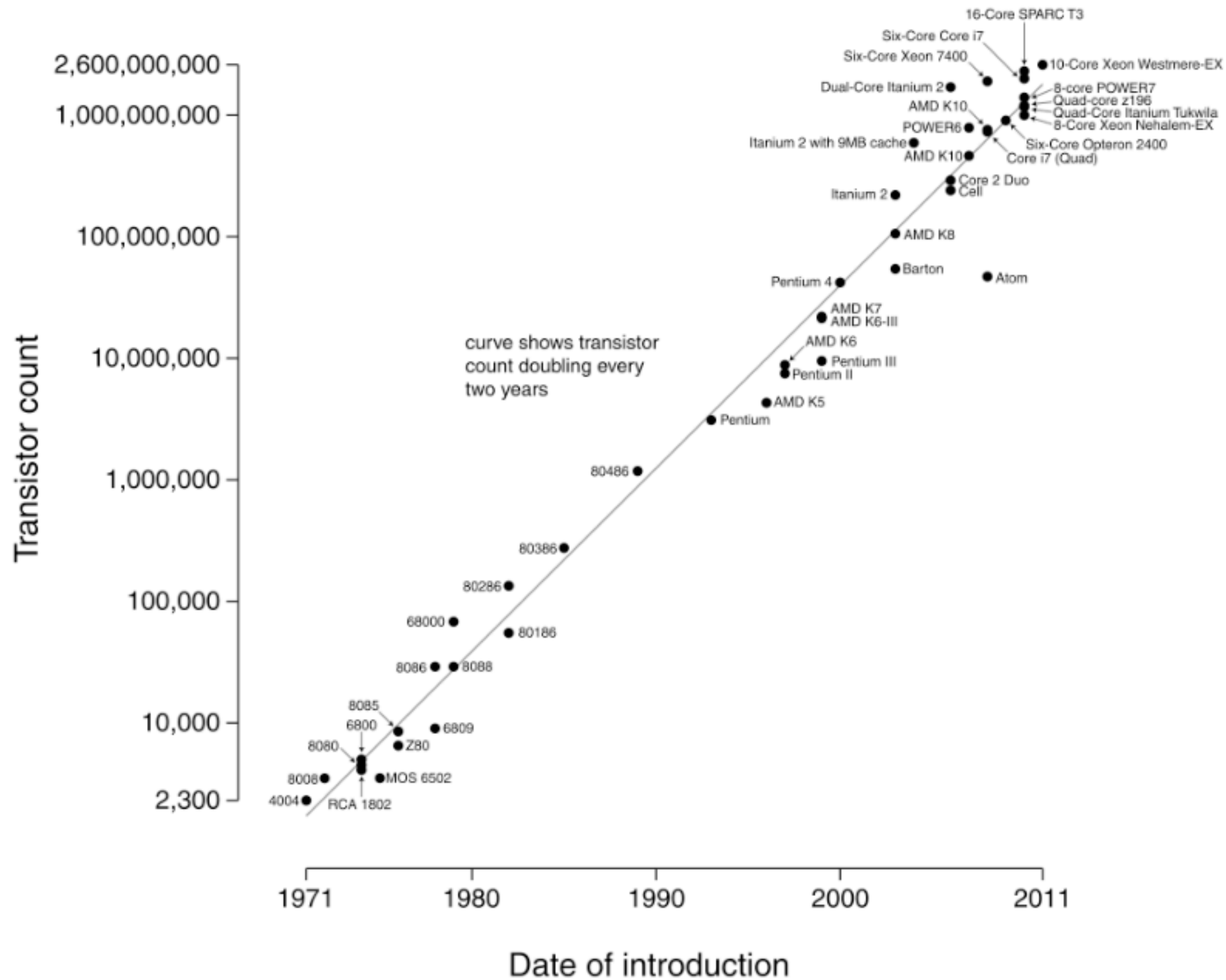
Heard often during live TV:  
“Dad, will you *pulee* fast forward through the commercials!!!”

**Log2 of the Number of Components  
Per Integrated Function**



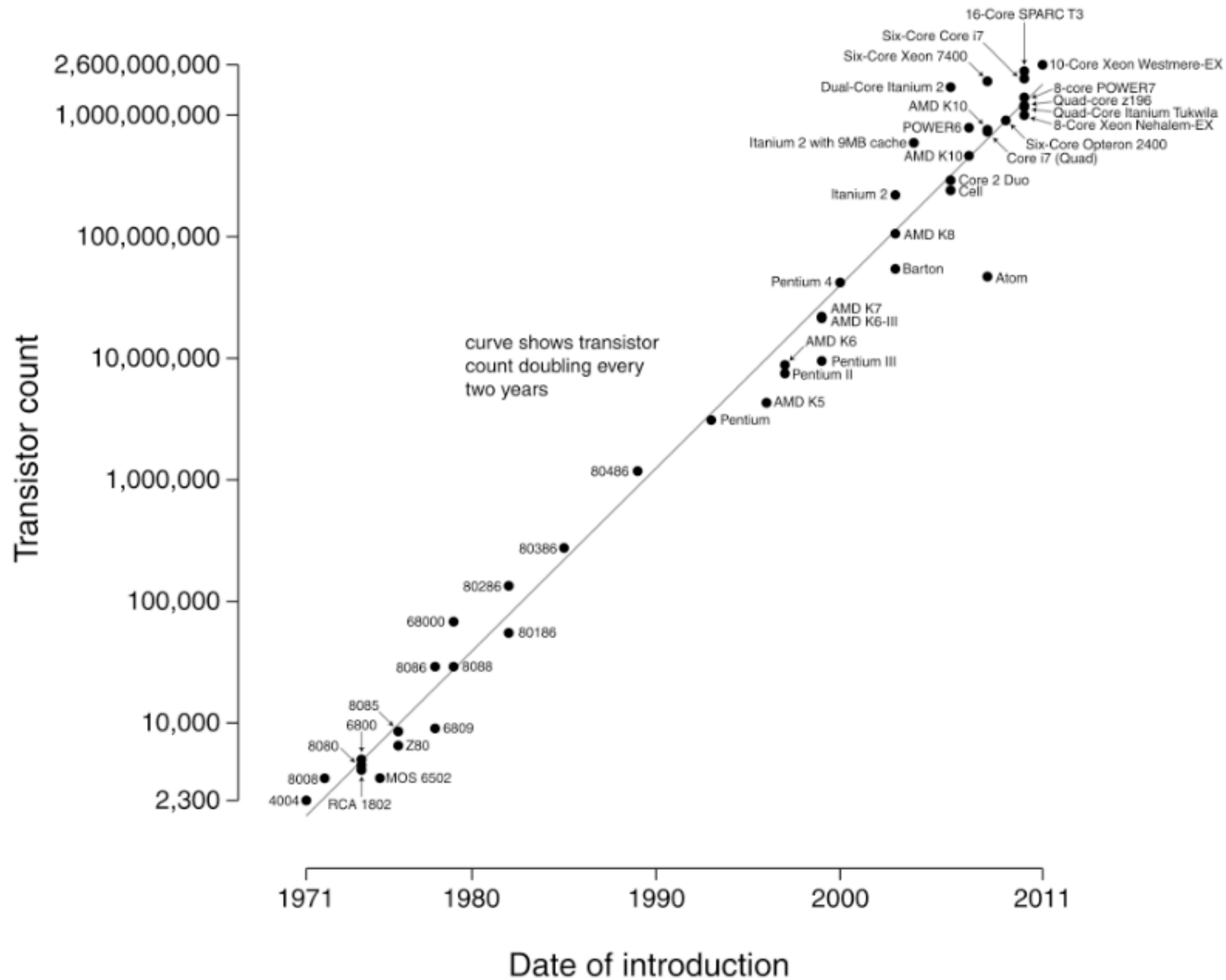
**Moore's Law**  
original 1965 paper

# Microprocessor Transistor Counts 1971-2011 & Moore's Law



Moore's Law  
original 1965 paper

# Microprocessor Transistor Counts 1971-2011 & Moore's Law



Moore's Law  
original 1965 paper

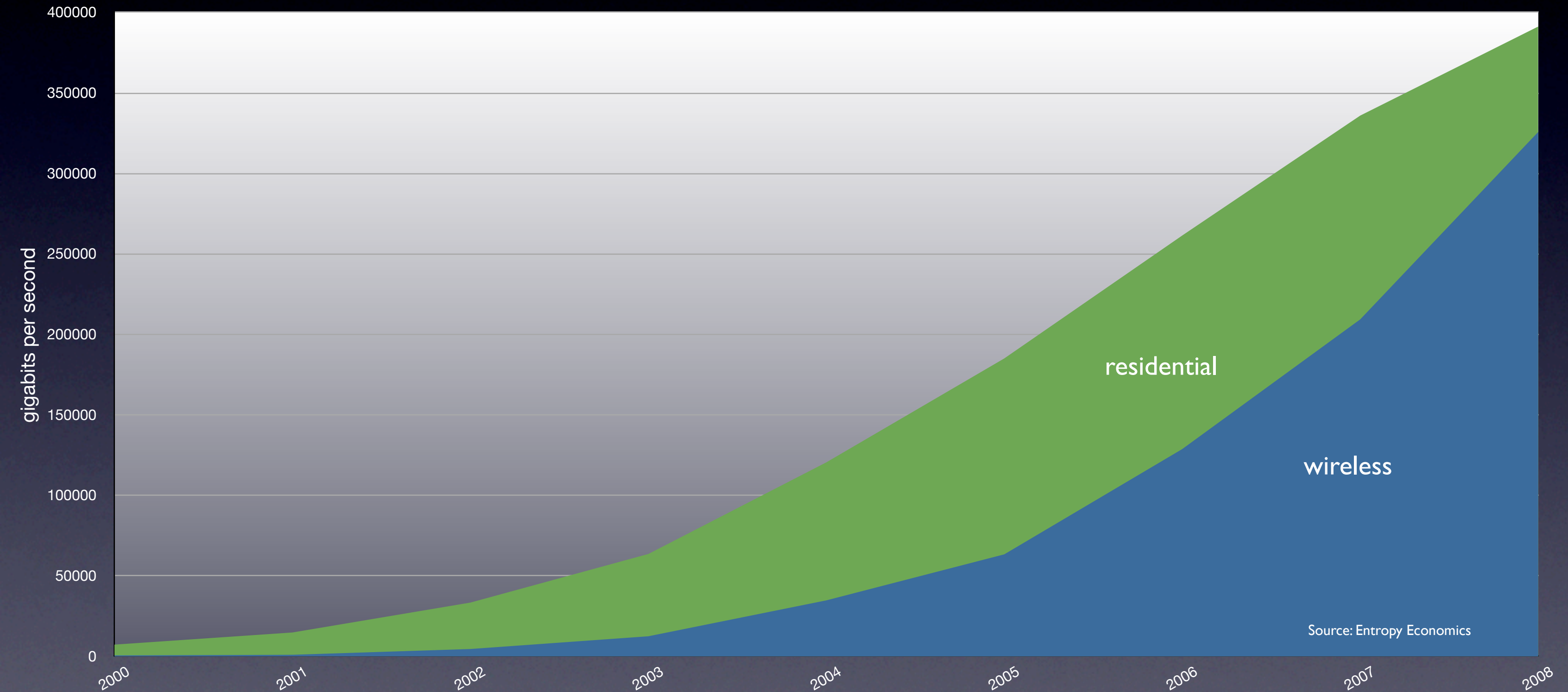
It still works,  
more or less



# Bandwidth Boom

ENTROPY ECONOMICS  
GLOBAL INNOVATION + TECHNOLOGY RESEARCH

## U.S. Consumer Bandwidth

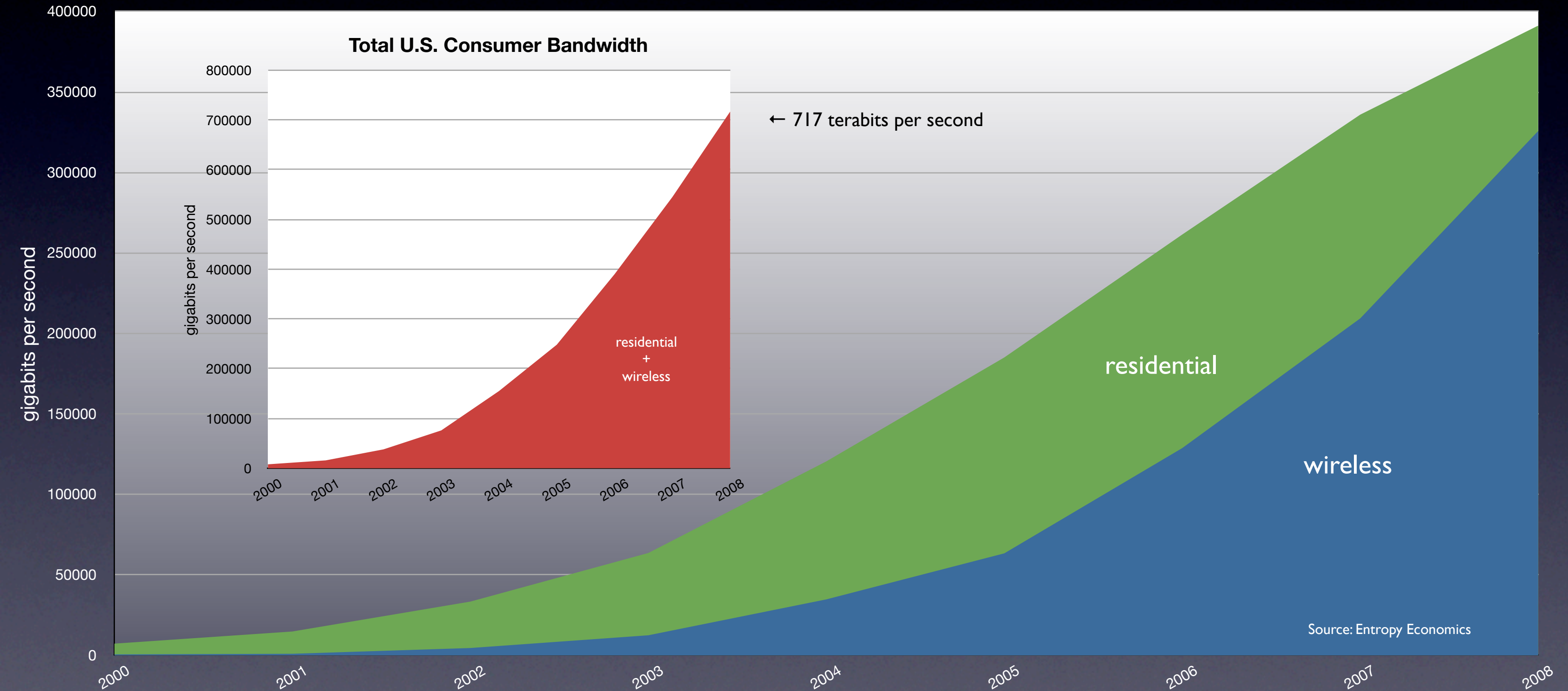




# Bandwidth Boom

ENTROPY ECONOMICS  
GLOBAL INNOVATION + TECHNOLOGY RESEARCH

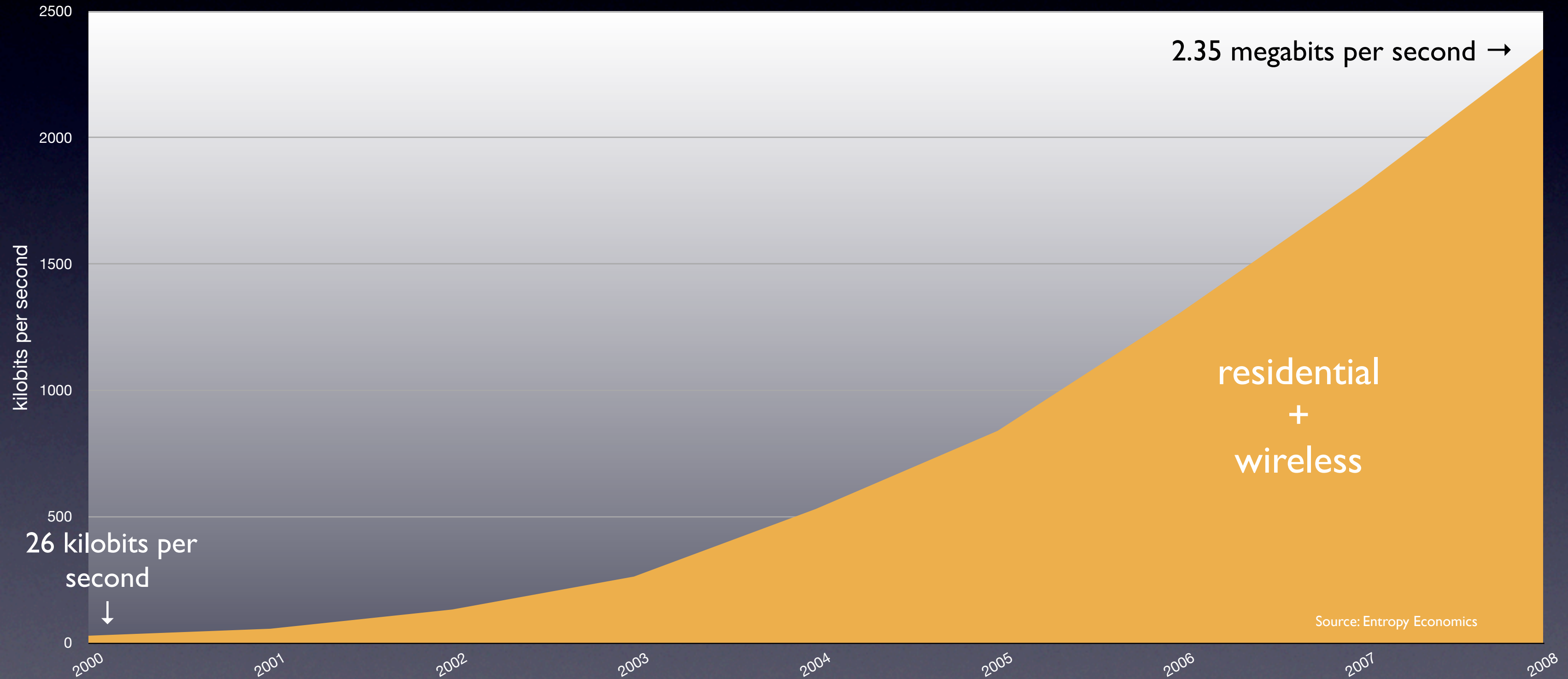
## U.S. Consumer Bandwidth



# Bandwidth Boom

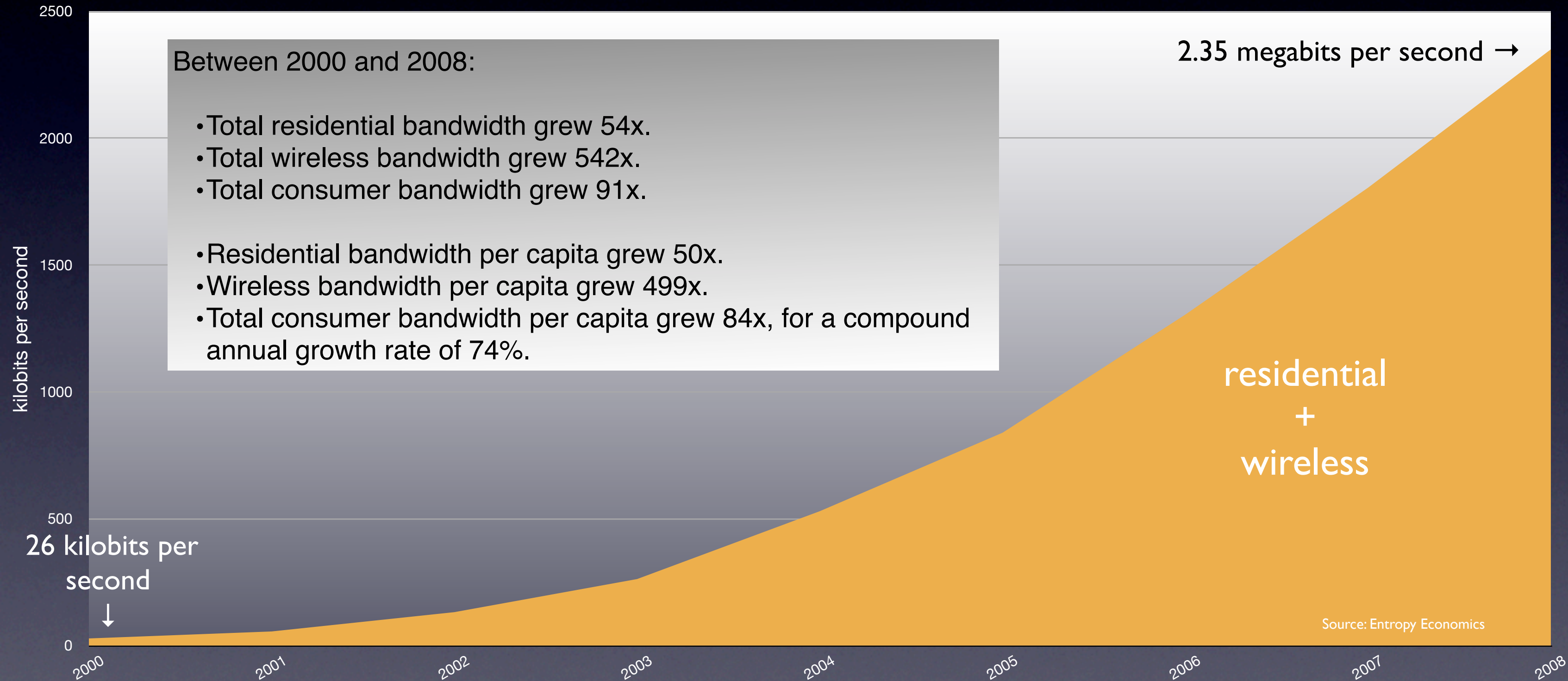
ENTROPY ECONOMICS  
GLOBAL INNOVATION + TECHNOLOGY RESEARCH

## U.S. Consumer Bandwidth Per Capita



# Bandwidth Boom

## U.S. Consumer Bandwidth Per Capita

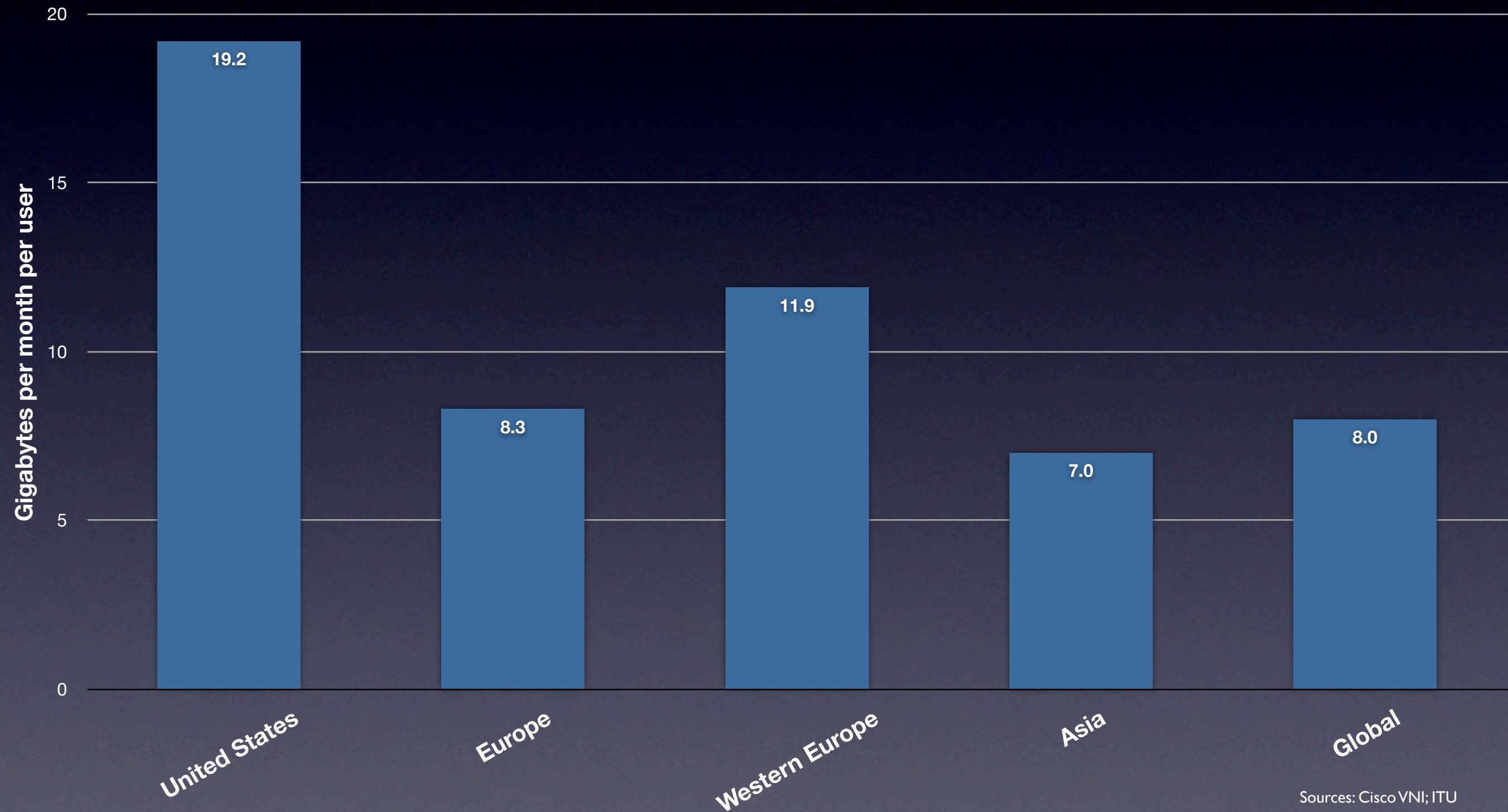




# International Broadband Comparison

ENTROPY ECONOMICS  
GLOBAL INNOVATION + TECHNOLOGY RESEARCH

IP Traffic per Internet User – 2010





# exaflood

Analyzing bandwidth and digital application trends, we projected a 56% compound annual growth rate through 2015 ...

...when U.S. IP traffic could reach:

■ Movie downloads and P2P.....	100	exabytes
■ Video calling and virtual windows.....	400	exabytes
■ “Cloud computing” and remote backup.....	50	exabytes
■ Net video, gaming, and virtual worlds.....	200	exabytes
■ Non-Internet “IPTV”.....	100+	exabytes
■ Business IP traffic.....	100	exabytes
■ Other (phone, Web, e-mail, photos, music).....	50	exabytes
■ Total.....	1,000	exabytes = 1 zettabyte



# Prefixes

kilo =  $10^3$

mega =  $10^6$

giga =  $10^9$

tera =  $10^{12}$

peta =  $10^{15}$

exa =  $10^{18}$

zetta =  $10^{21}$



update

# exaflood

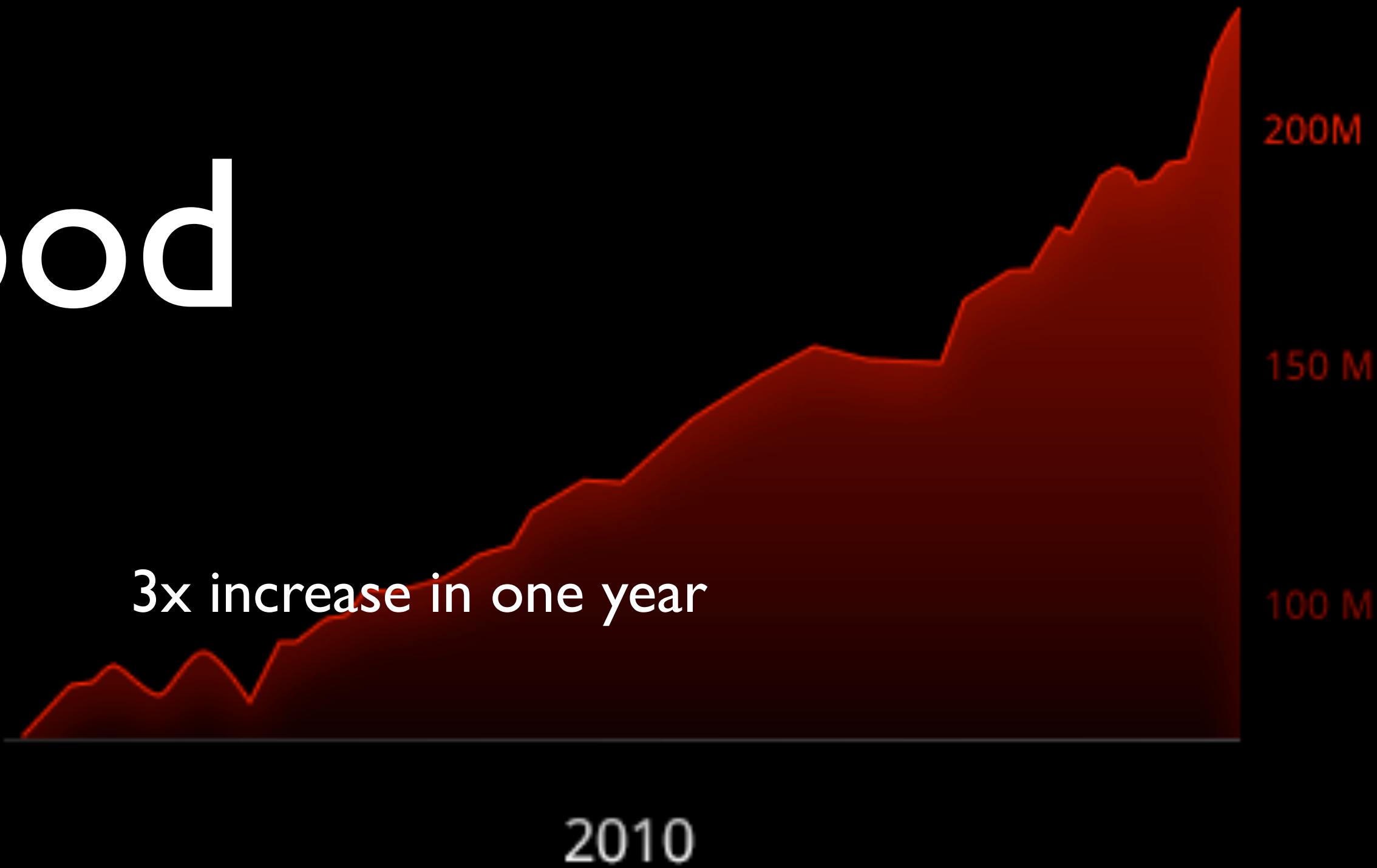
## YouTube

- > receives uploads of 24+ hours of video every minute
- > receives 34,560+ hours of video each day
- > streams 1+ B videos per day or ~300+ **petabytes** per month
- > streams 200 million *mobile* videos/day, up 3-fold since January 2010
- > streams ~7 **terabytes** every minute ... every 6.5 min. = 1992
- > HD YouTube would mean 20+ **exabytes** per year,  
more than total U.S. Internet traffic of 2008
- > Netflix would ship about 10 **exabytes** of HD video each year

update

# You Tube Mobile Video Playbacks

exaflood

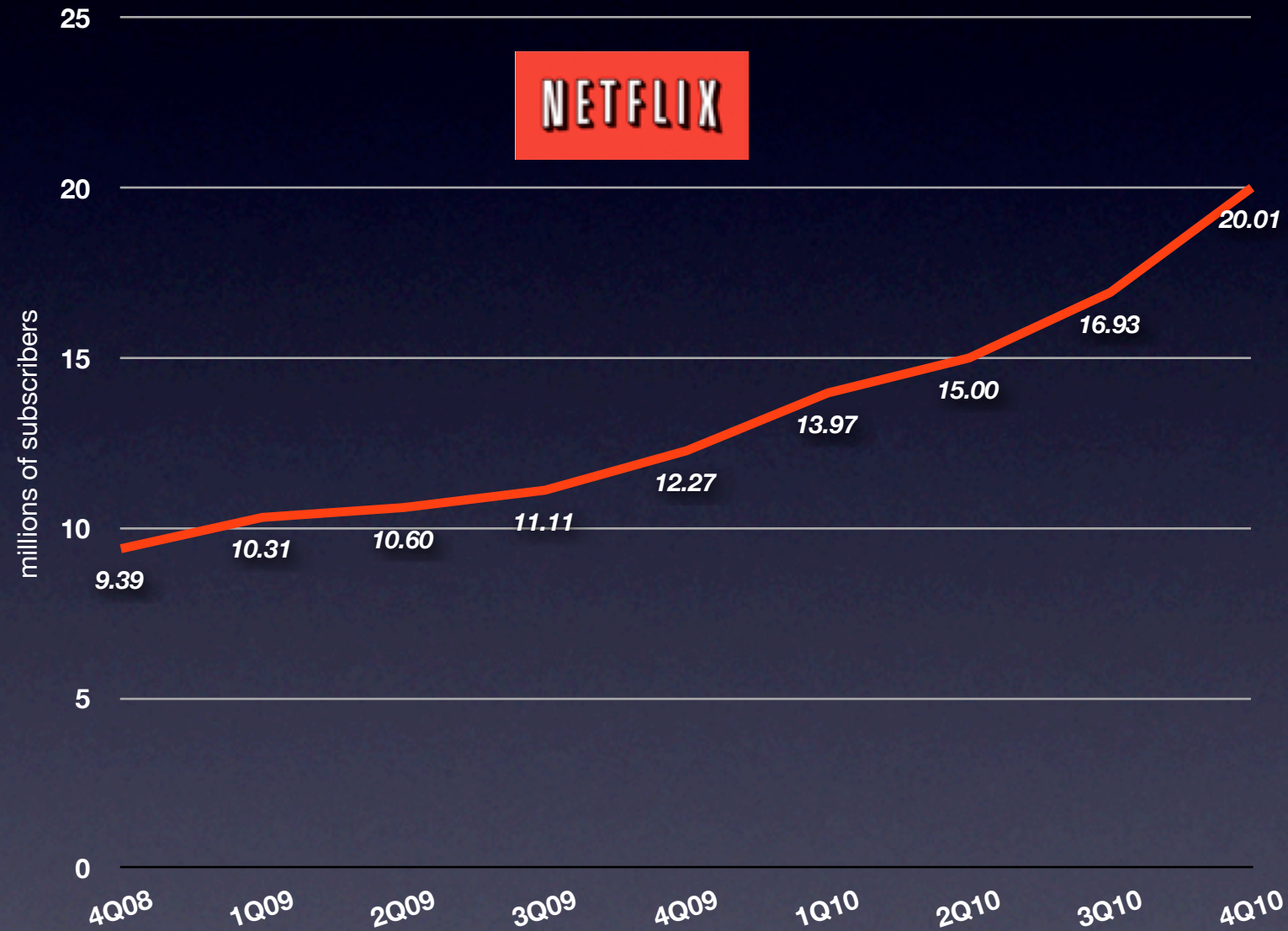




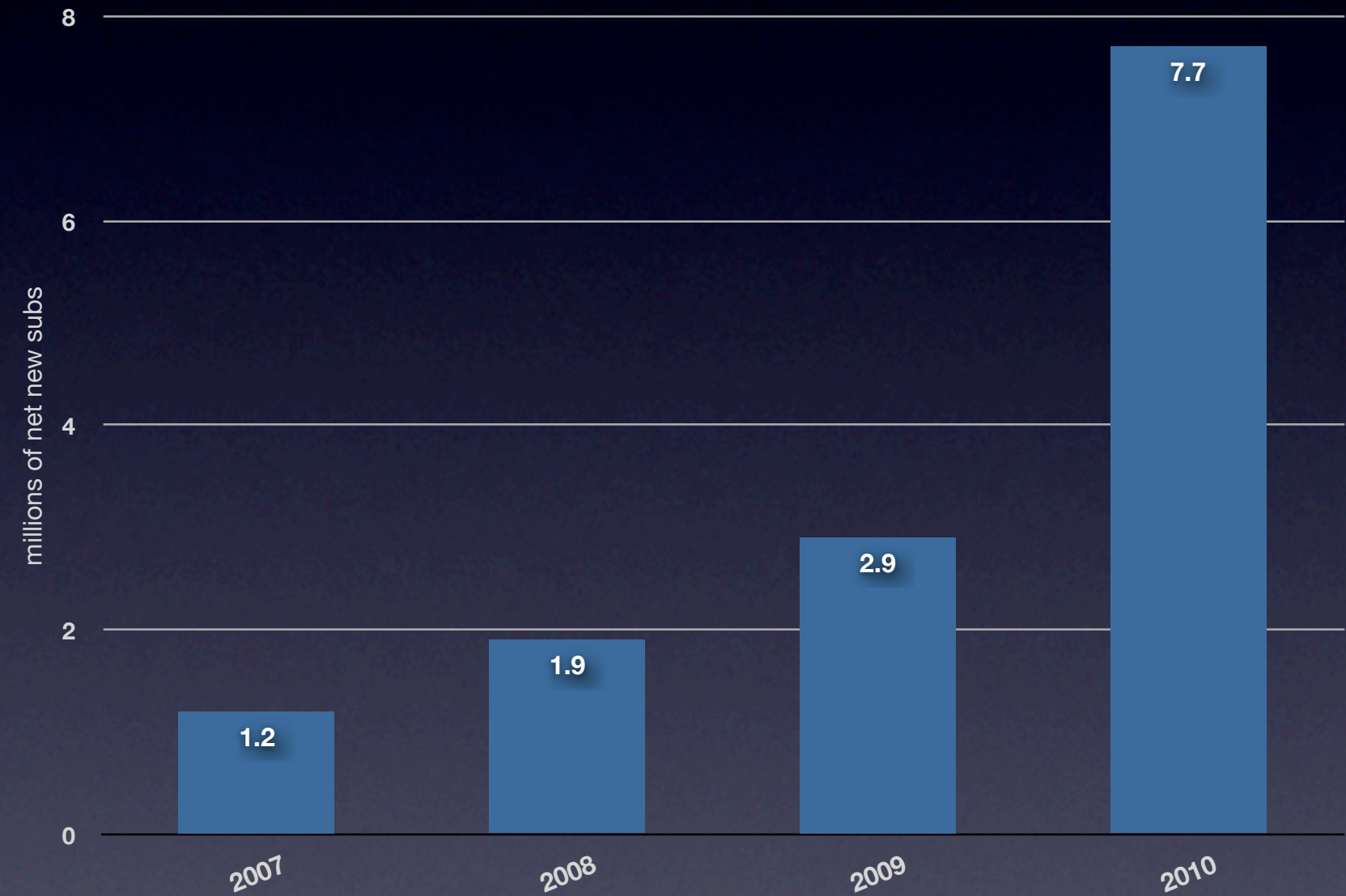
update

# exaflood

Netflix Total Subscribers



Accelerating Net New Subscribers



Netflix online streams grew to 200 million in Jan 2011 – up 38% in just one month, since Dec 2010.



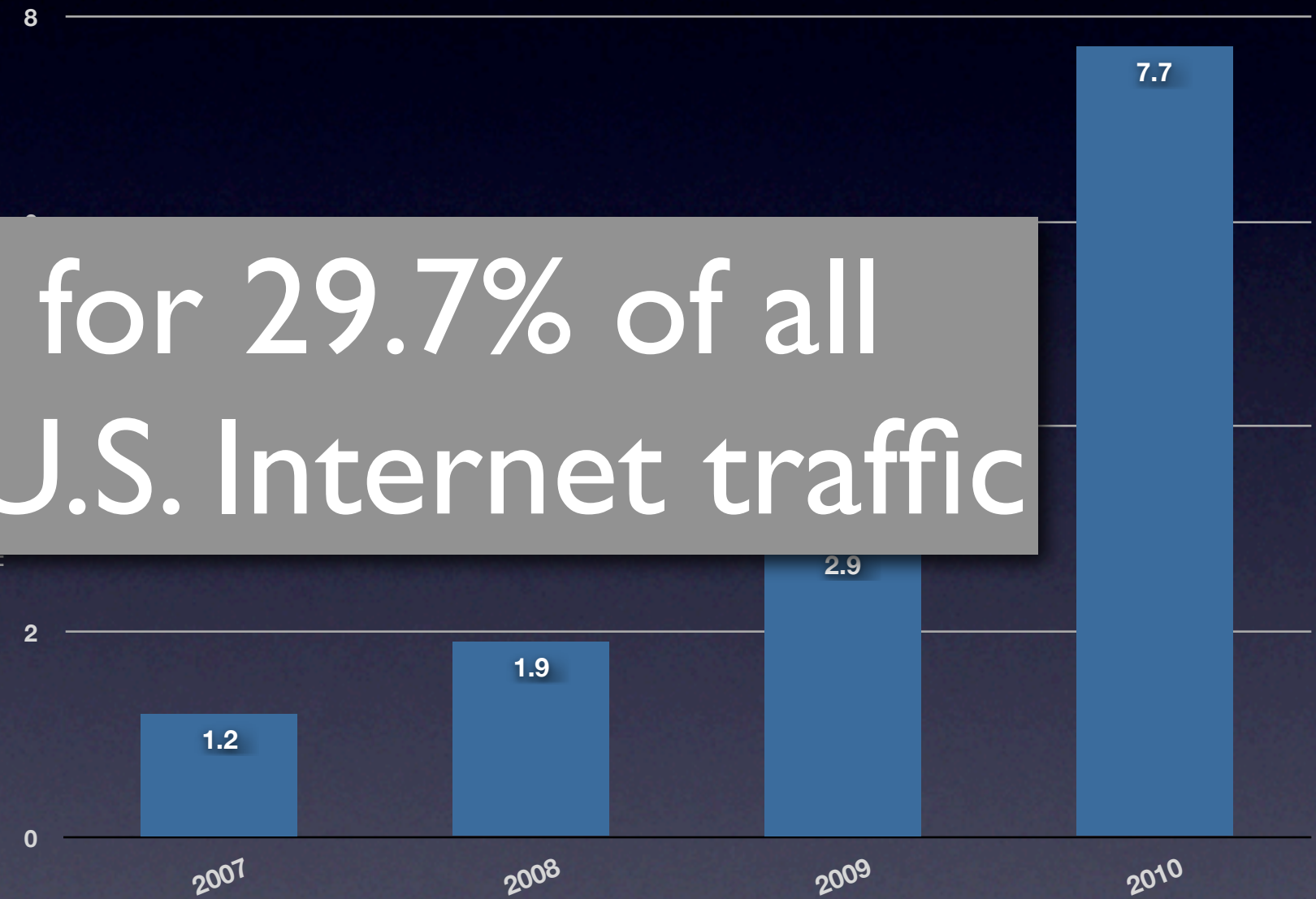
update

# exaflood

Netflix Total Subscribers



Accelerating Net New Subscribers



Netflix accounts for 29.7% of all peak downstream U.S. Internet traffic

Netflix online streams grew to 200 million in Jan 2011 – up 38% in just one month, since Dec 2010.

update

# exaflood

Netflix Total Subscribers

Accelerating Net New Subscribers



Netflix online streams grew to 200 million in Jan 2011 – up 38% in just one month, since Dec 2010.



update

# exaflood

## Mobile Revolution

- > 4 billion mobile phones / 1+ billion new devices per year / soon **10 billion** mobile devices worldwide
- > 2.5 billion camera phones / Nokia largest “camera” company / Apple may soon displace as largest “camera” company (most flickr photos)
- > 14 billion iPhone App downloads in 2 years ... 450,000 Apps
- > “omnichronnectivity” yields constant content creation and consumption / iPhone video recorder literally records history
- > iPad is whole new content platform paradigm (15 MM sold in 9 mos)
- > Cisco: 26-fold increase in mobile data thru 2015 (CAGR = 92%)

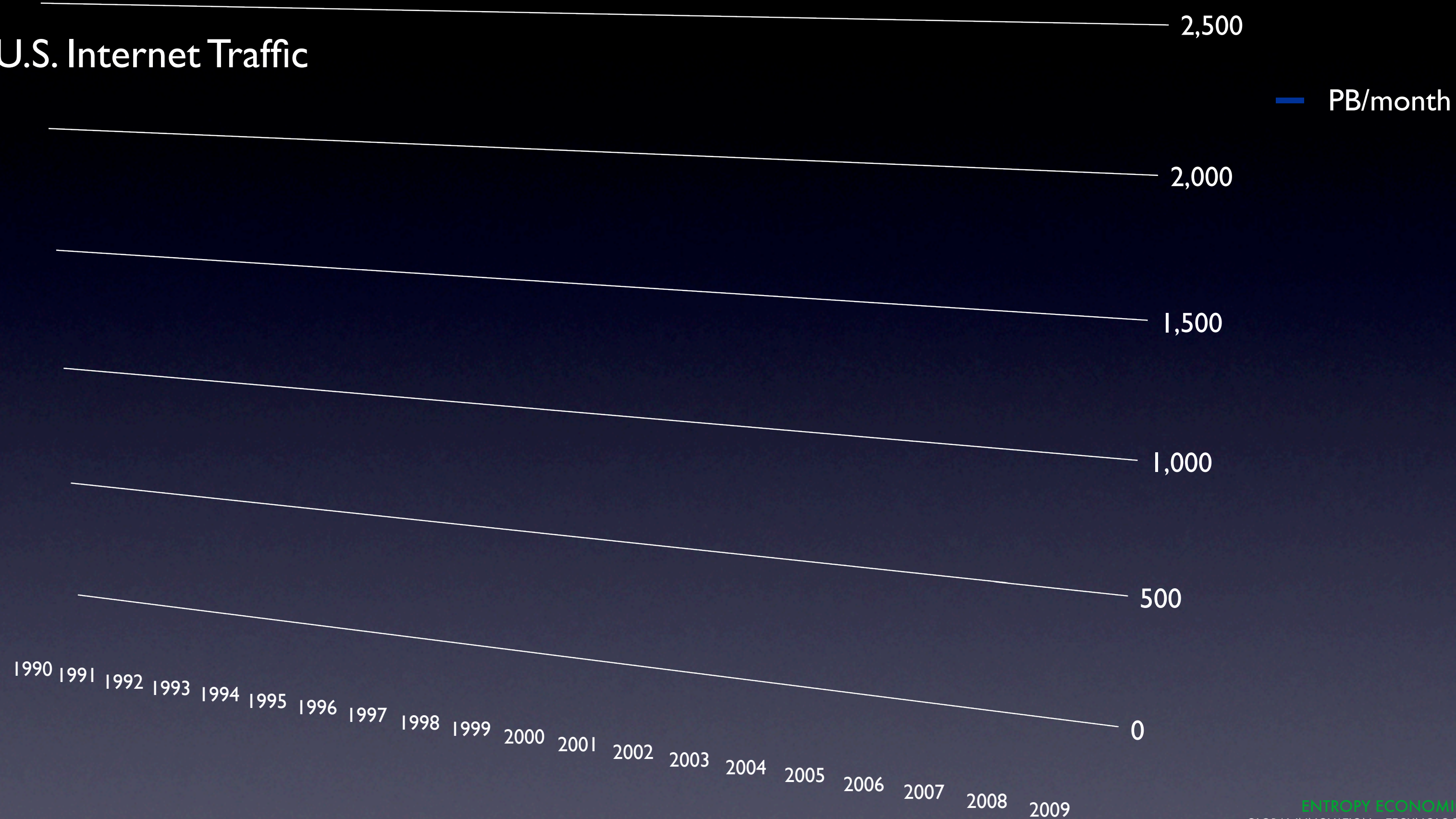


# U.S. Internet Traffic

— PB/month

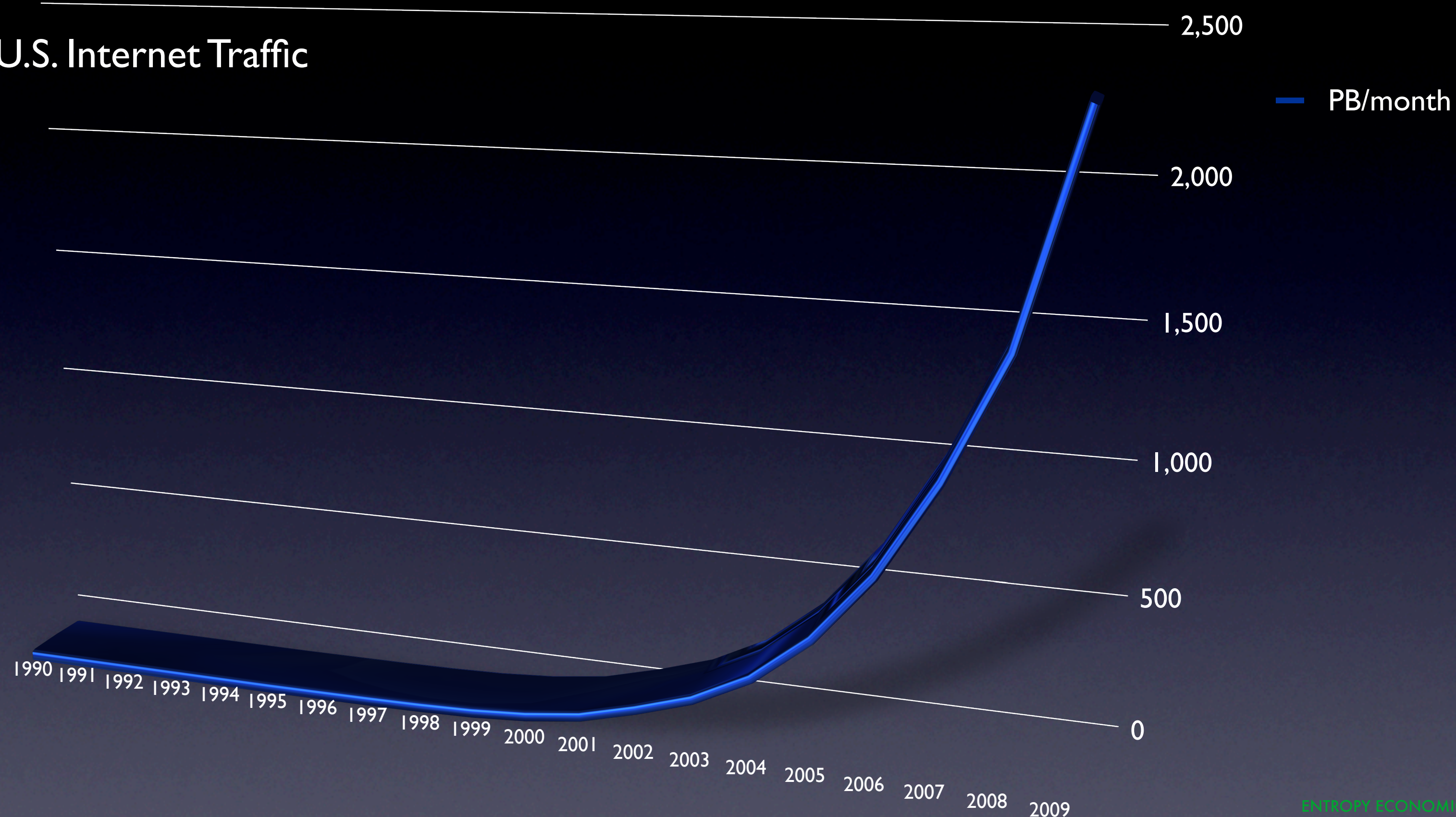


# U.S. Internet Traffic





# U.S. Internet Traffic





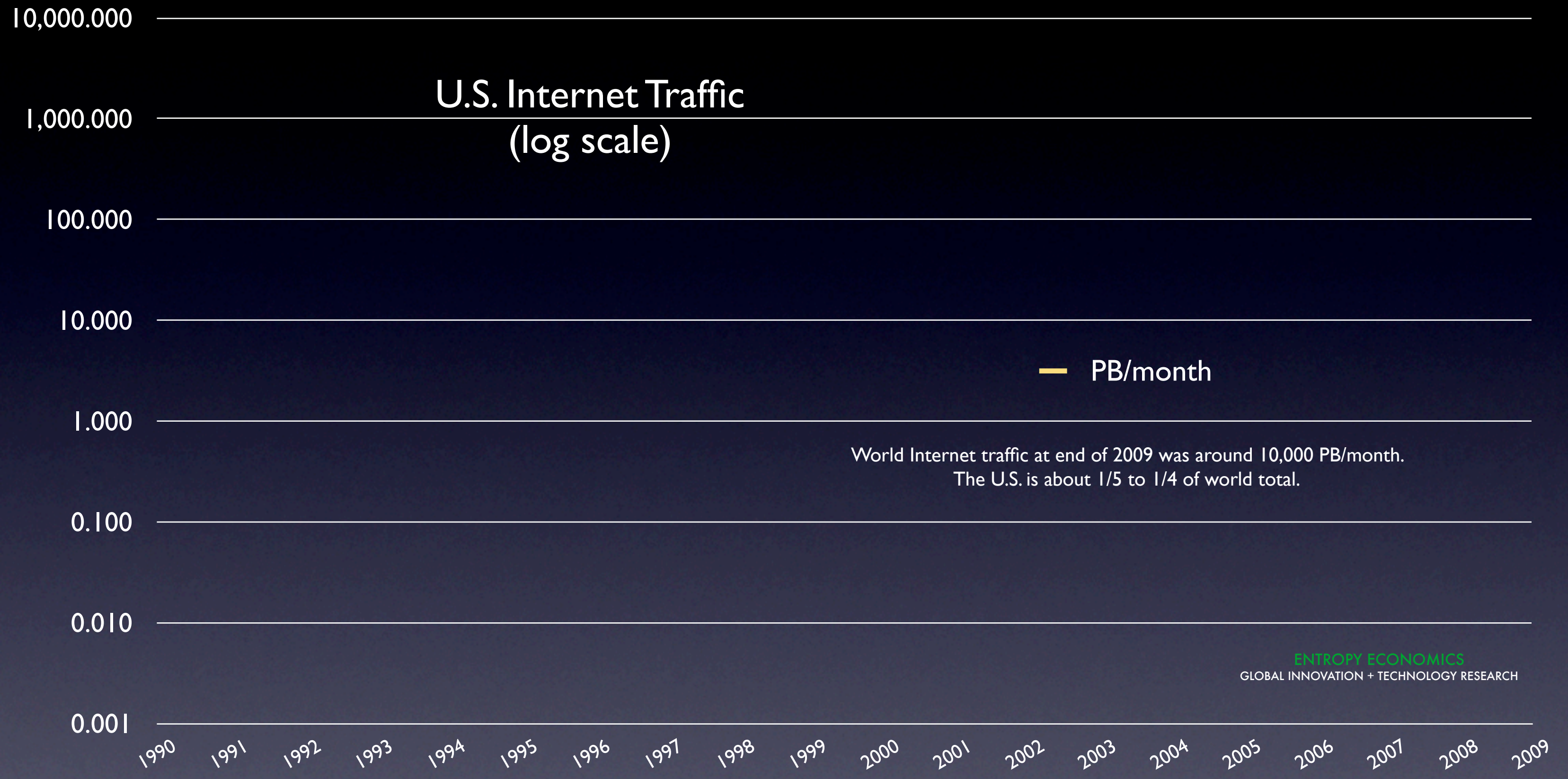
# U.S. Internet Traffic (log scale)

— PB/month

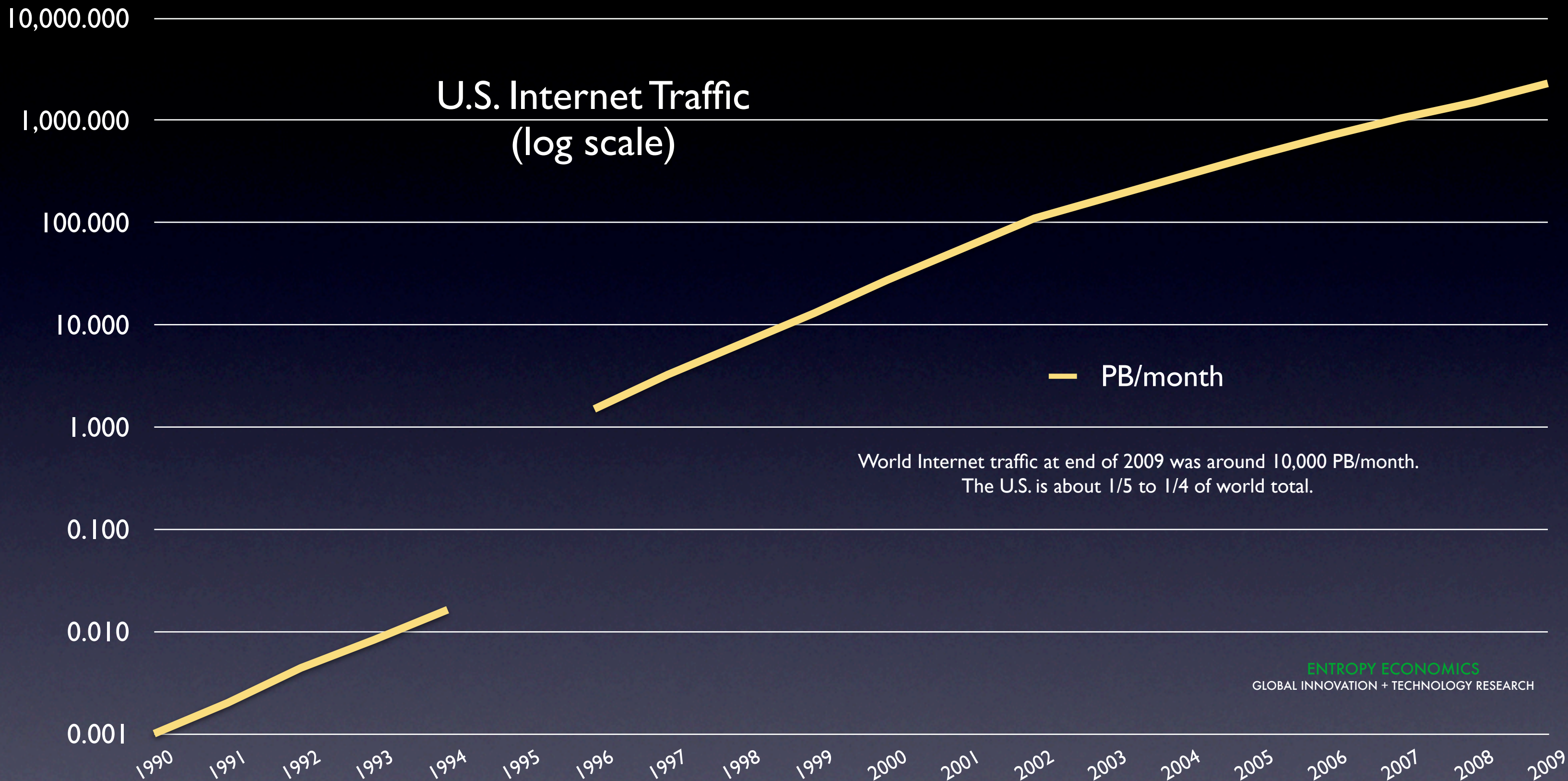
World Internet traffic at end of 2009 was around 10,000 PB/month.  
The U.S. is about 1/5 to 1/4 of world total.

ENTROPY ECONOMICS  
GLOBAL INNOVATION + TECHNOLOGY RESEARCH



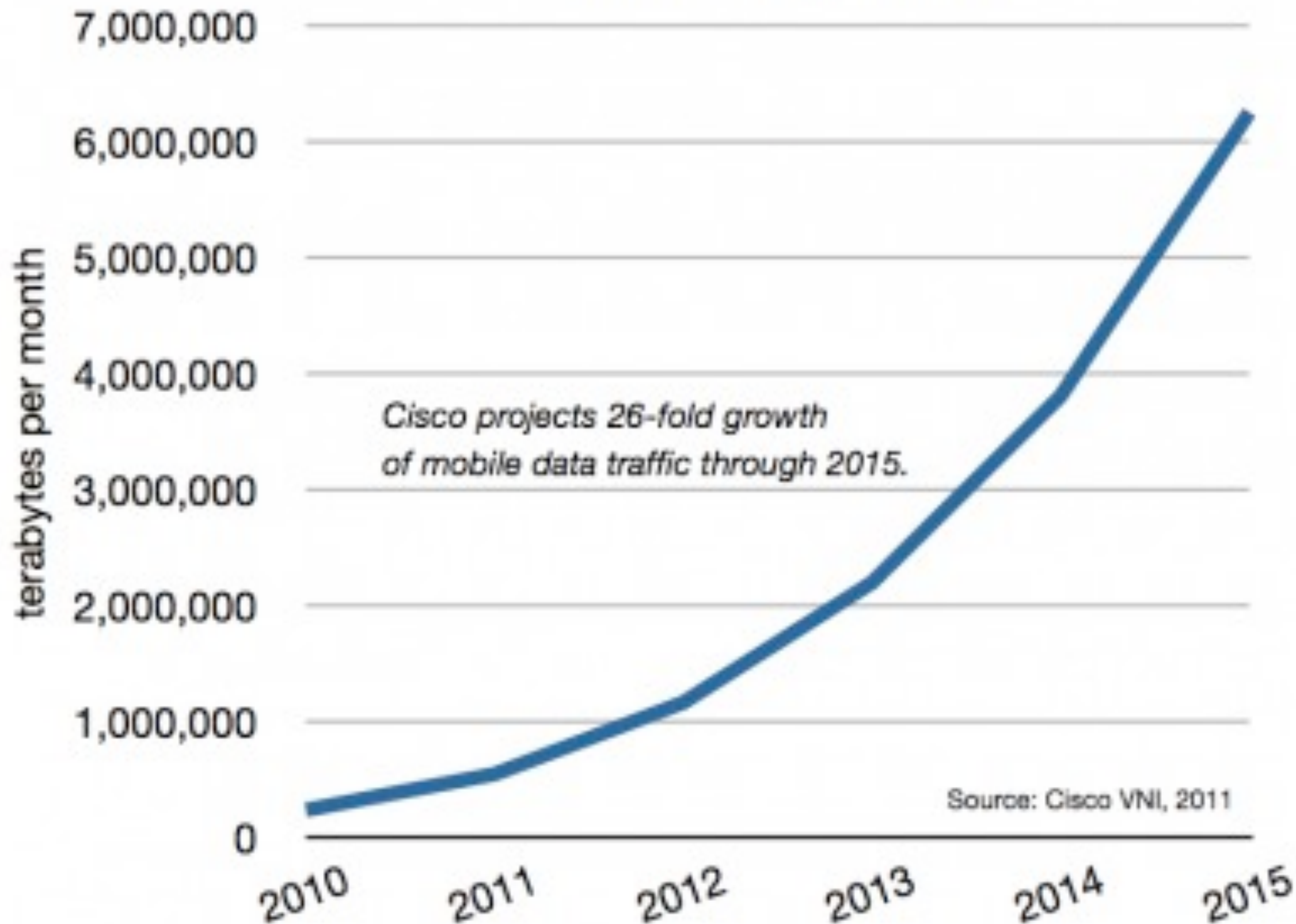








## Wireless Exaflood



Mobile Data  
Traffic Growth

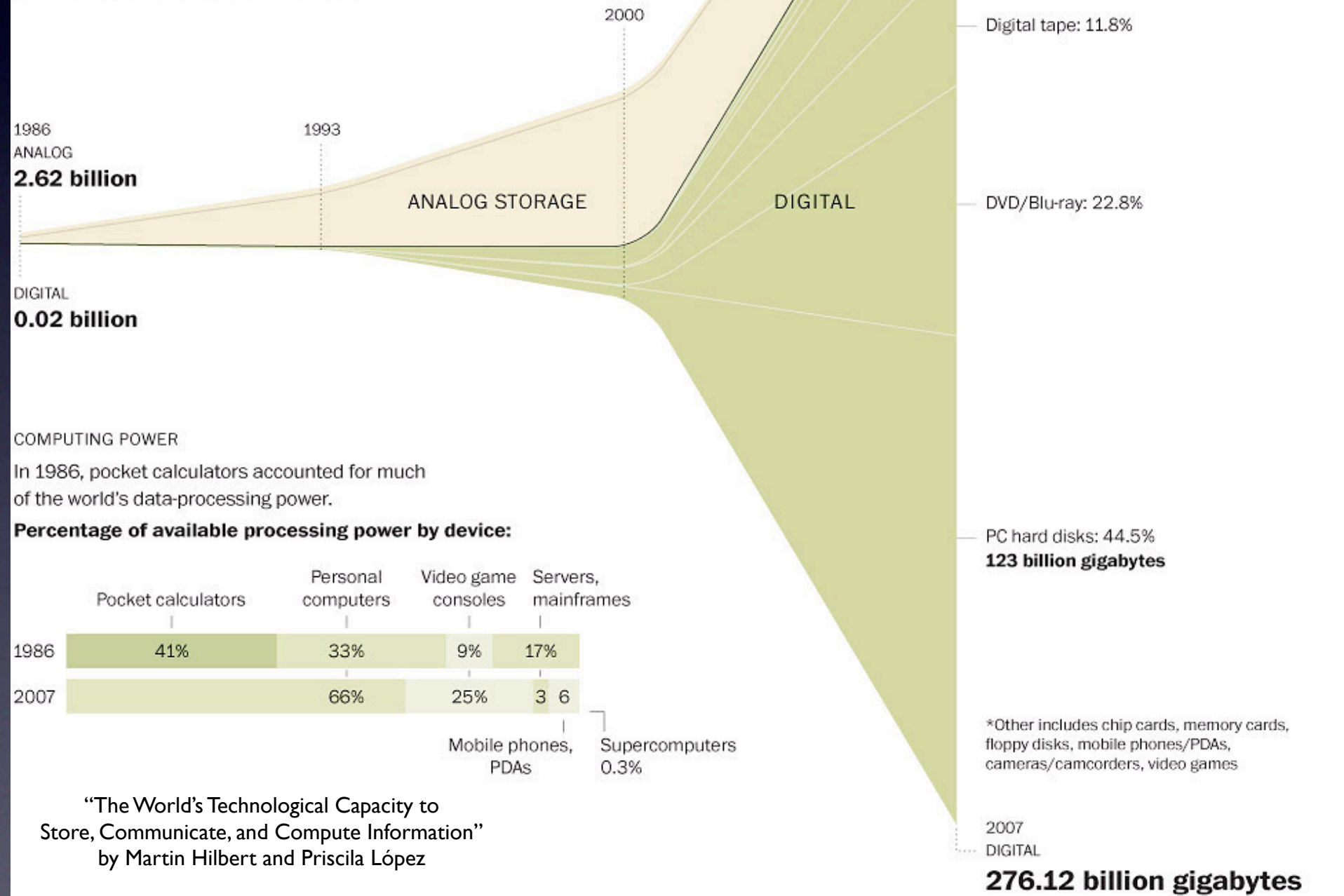


# Digital Boom

## THE WORLD'S CAPACITY TO STORE INFORMATION

This chart shows the world's growth in storage capacity for both analog data (books, newspapers, videotapes, etc.) and digital (CDs, DVDs, computer hard drives, smartphone drives, etc.)

In gigabytes or estimated equivalent



“The World’s Technological Capacity to Store, Communicate, and Compute Information”  
by Martin Hilbert and Priscila López

exaflood

digitization of music

digital cameras arrive  
~2000

graphics processors

iPhone video  
recorders

PC terabyte drives



# exaflood

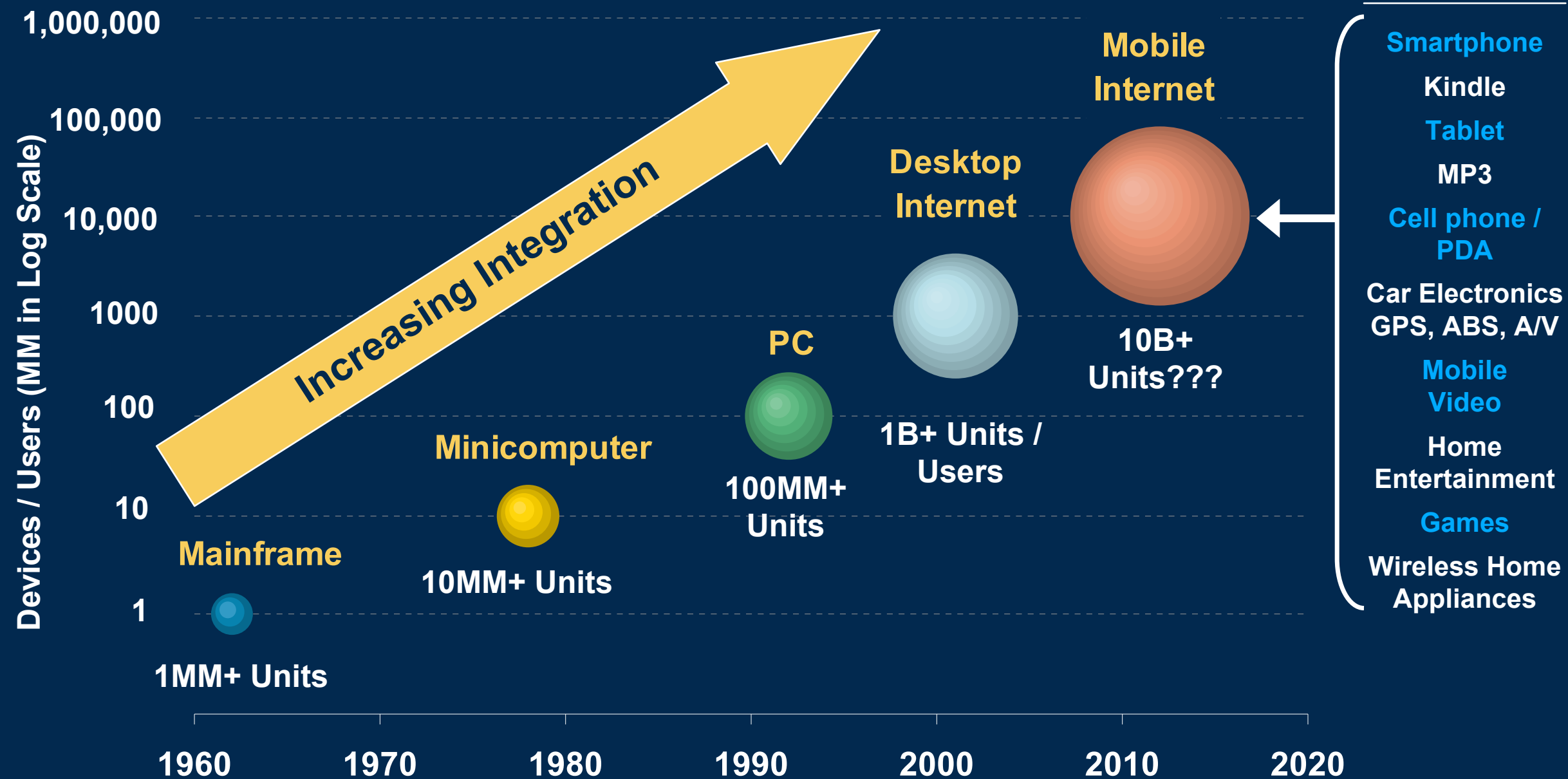




# New Computing Cycle Characteristics

Reduce Usage Friction Via Better Processing Power + Improved User Interface +  
Smaller Form Factor + Lower Prices + Expanded Services = 10x More Devices

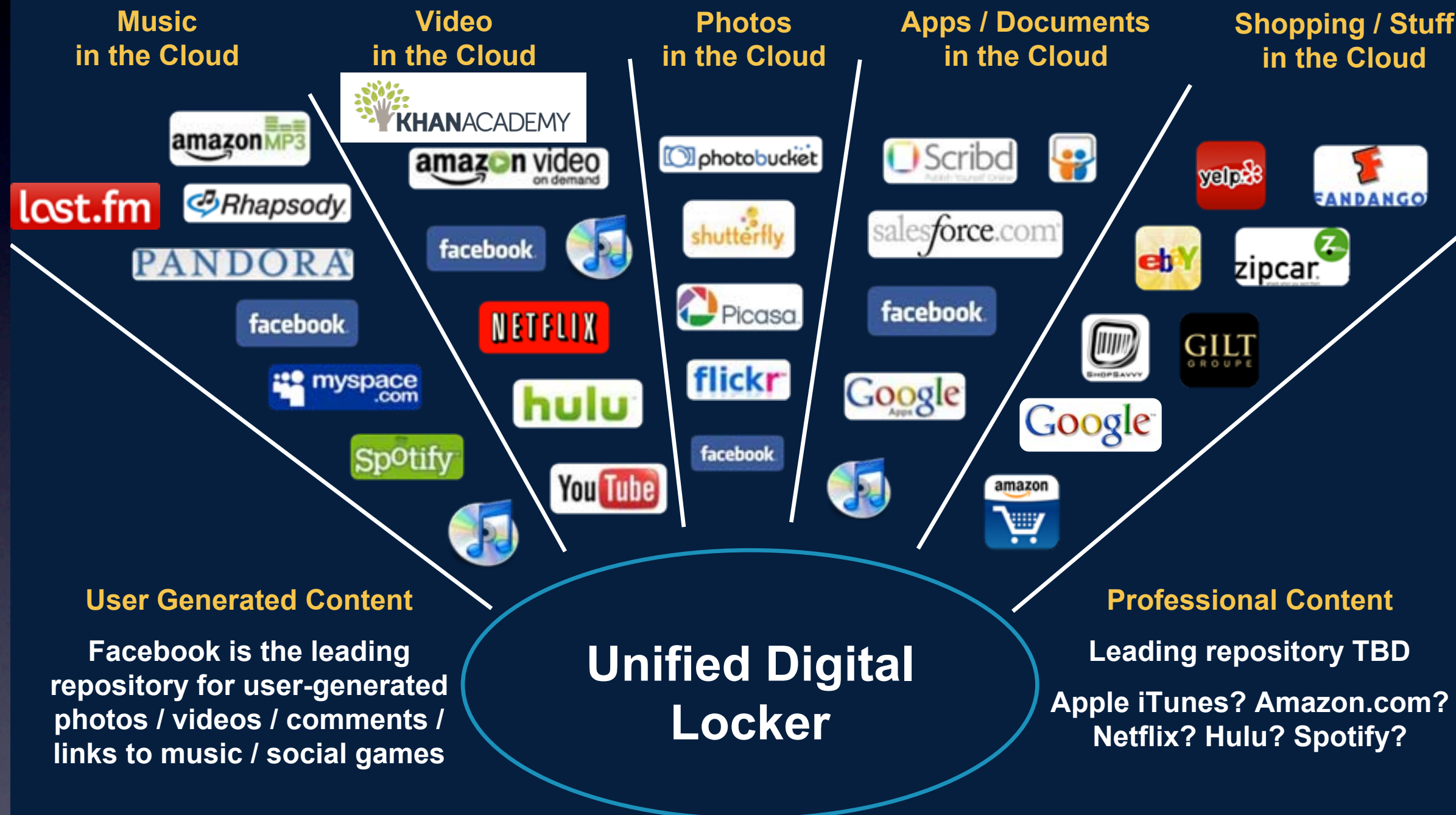
Computing Growth Drivers Over Time, 1960 – 2020E



10 billion  
mobile Internet  
devices  
later this year

# Connectivity = Cloud Computing

## Consumers Expect to Get Their Stuff 24x7 from Palms of Their Hands





**amazon.com** now sells more ebooks than paper books

**amazon.com** now sells more ebooks than paper books

Since April 1, 2011, it has sold 105 ebooks for every 100 paper books







University of Phoenix®



MITOPENCOURSEWARE  
MASSACHUSETTS INSTITUTE OF TECHNOLOGY





MITOPENCOURSEWARE  
MASSACHUSETTS INSTITUTE OF TECHNOLOGY







**KHAN**  
ACADEMY

MIT **OPEN**COURSEWARE  
MASSACHUSETTS INSTITUTE OF TECHNOLOGY



University of Phoenix®

# Indian Math Online

Engaging Students. Empowering Parents

Price of higher education has increased 440% over last 25 years

That's four times the rate of inflation

And double the increase in health care



Price of higher

T

A

Now it is true that college-educated people normally earn more than non-college-educated folks. But over the past two decades the costs of university education – tuition, room, board and fees – have increased at a rate six times greater than the increase in the average earnings of college graduates. And in the past decade college graduates' earnings have actually fallen. The value proposition is on a downward trajectory.

er last 25 years

n

re

– Louis Lataif, Boston Univ.

Price of higher

T

Now it is true that college-educated people normally earn more than non-college-educated folks. But over the past two decades the costs of university education – tuition, room, board and fees – have increased at a rate six times greater than the increase in the average earnings of college

er last 25 years

**U.S. student debt = \$830 billion ... more than U.S. credit card debt**

A

college graduates' earnings have actually fallen. The value proposition is on a downward trajectory.

re

– Louis Lataif, Boston Univ.

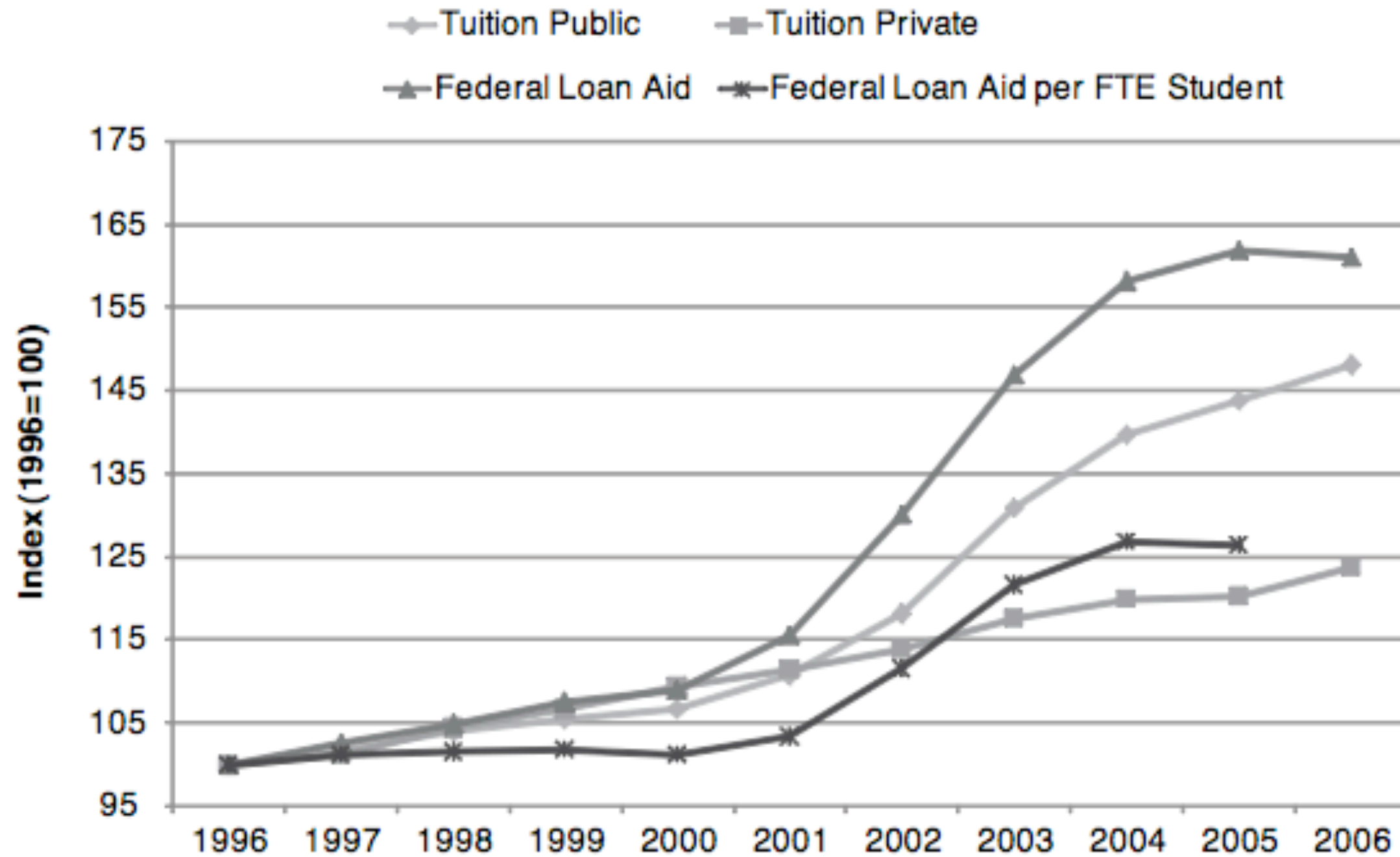


Tuition and fees going up

Return on investment for many students is questionable

Budgets of families, states, and nation are tapped out

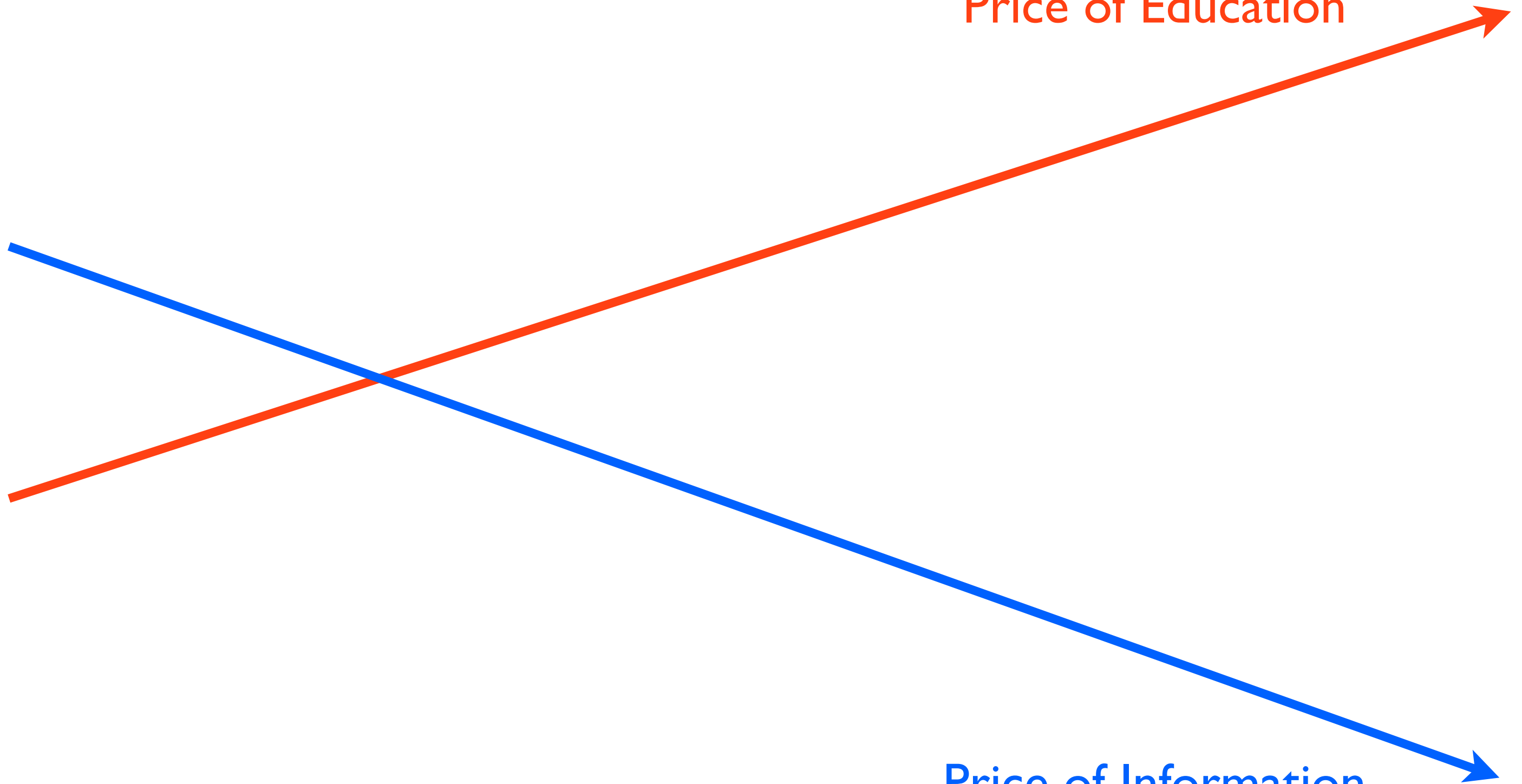
## TUITION AND FEDERAL LOAN AID



Sources: *Digest of Education Statistics*, tables 320 and 210; College Board, *Trends in Student Aid 2007*; Bureau of Labor Statistics, CPI-U; and CCAP calculations.



Price of Education

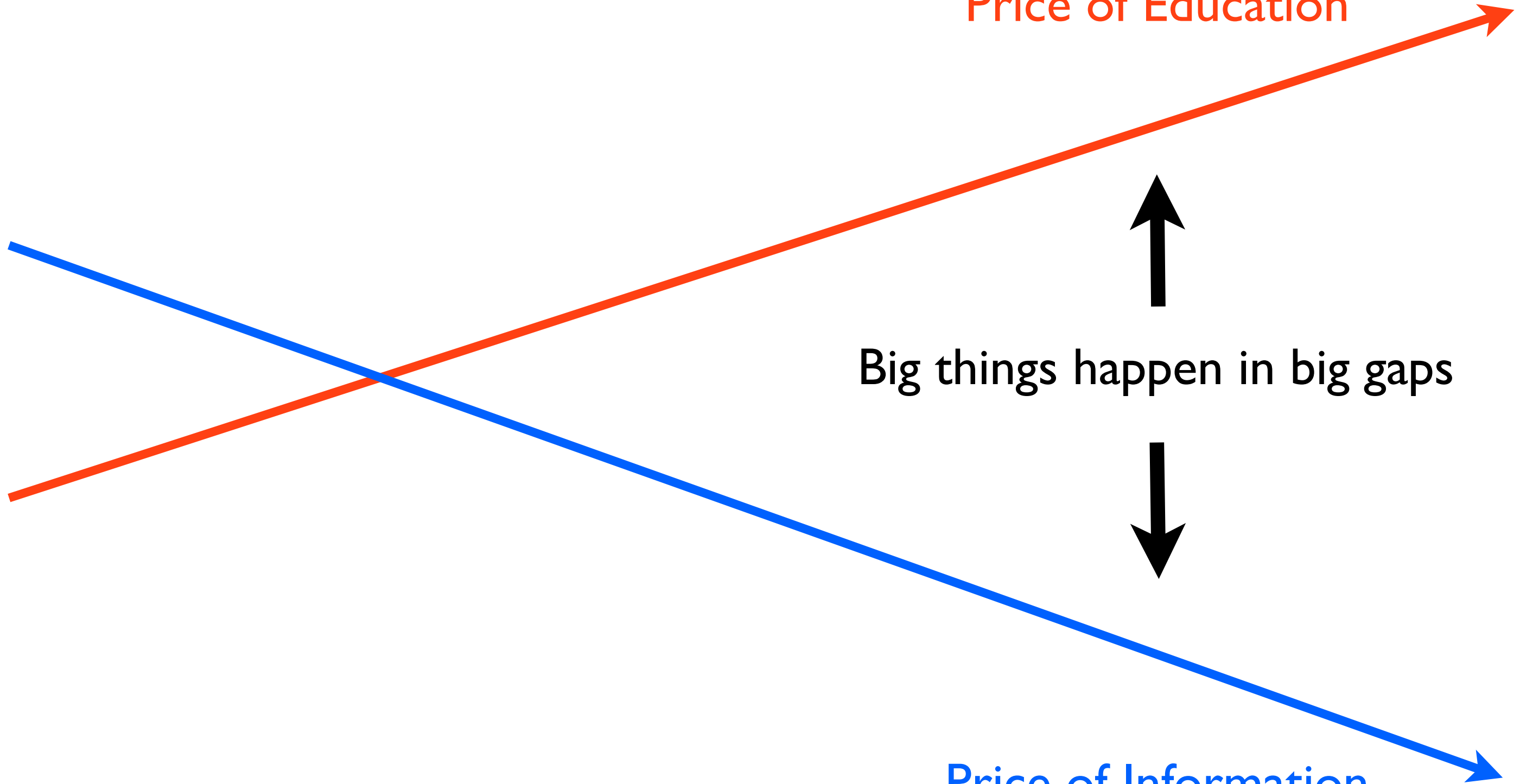


Price of Information

Price of Education

Big things happen in big gaps

Price of Information





Information

$\neq$

Education

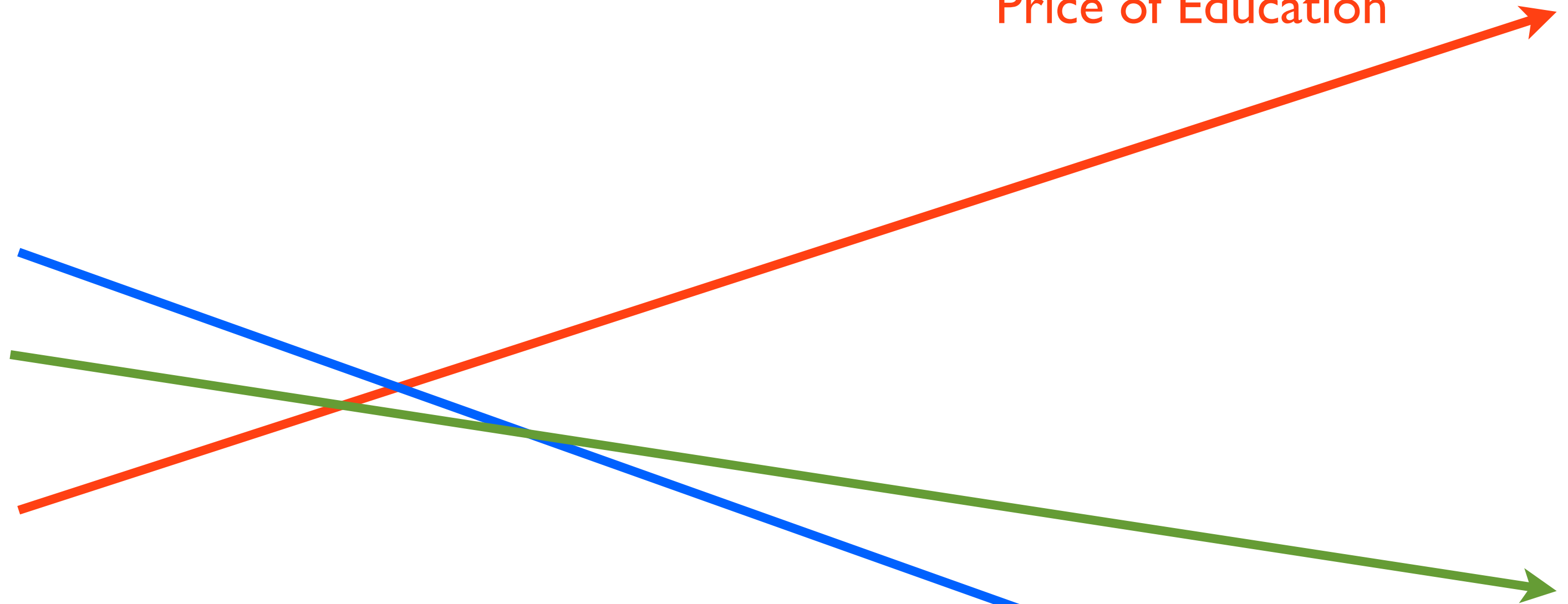
# The Original University Model

was based on the geography of information

1. Library – access to information
2. Student proximity to professors
3. Professor proximity to other professors



Price of Education



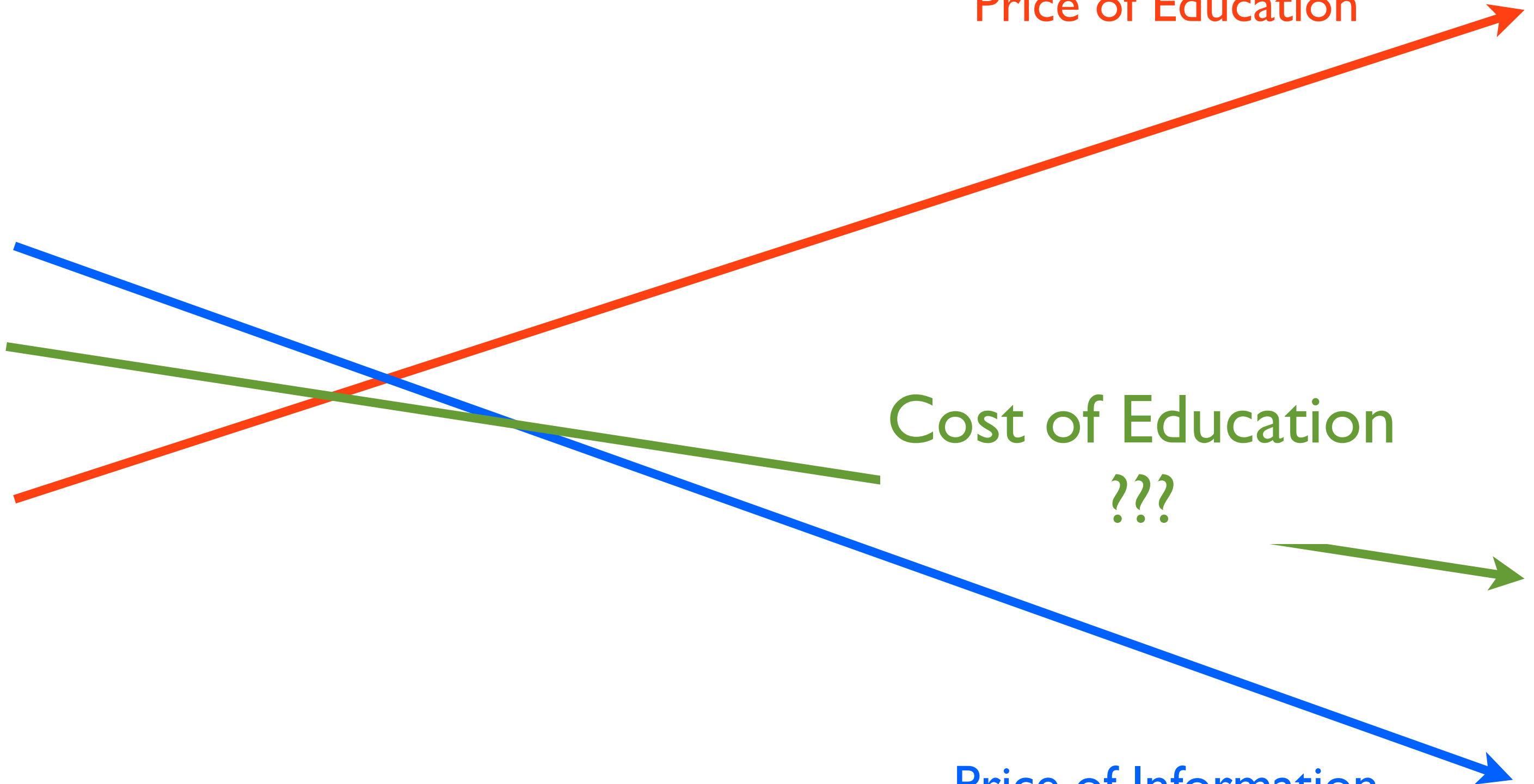
Price of Information

Price of Education

Cost of Education

???

Price of Information





What is education?

What is merely information?

What is instruction?

What is “college”?

What is vo-tech?

What is value?

How do we measure?

What is a college's product? What does it seek to maximize?

What do employers want?

- Four-year BAs
- particular skills

What do young people want?

- liberal education
- good jobs and good life

What does America need?



# America's Two Productivity Disasters

1. Health Care
2. Education

# America's Two Productivity Opportunities

1. Health Care
2. Education



# A One-Man Global School





# A One-Man Global School

2,100 lessons ...  
... in math, science, history, economics



## A One-Man Global School

2,100 lessons ...  
... in math, science, history, economics

from addition to linear algebra ...  
... from earth science to organic chemistry



# A One-Man Global School

2,100 lessons ...  
... in math, science, history, economics

from addition to linear algebra ...  
... from earth science to organic chemistry

exercises and assessments





A One-Man Global School

2,100 lessons ...  
... in math, science, history, economics

from addition to linear algebra ...  
... from earth science to organic chemistry

exercises and assessments

as of noon today ... 59,663,083 lessons delivered



**KHAN**  
ACADEMY

[Previous Video: Epsilon Delta Limit Definition 2](#)

[Next Video: Calculus: Derivatives 2 \(new HD version\)](#)

Calculus: Derivatives 1 (new HD version)  
by Khan Academy

$\text{slope} = \frac{\Delta y}{\Delta x} = \frac{f(b) - f(a)}{b - a}$

$\frac{7 - 3}{5 - 2} = \left[ \frac{4}{3} \right] \leftarrow \text{slope}$

$\text{slope} =$

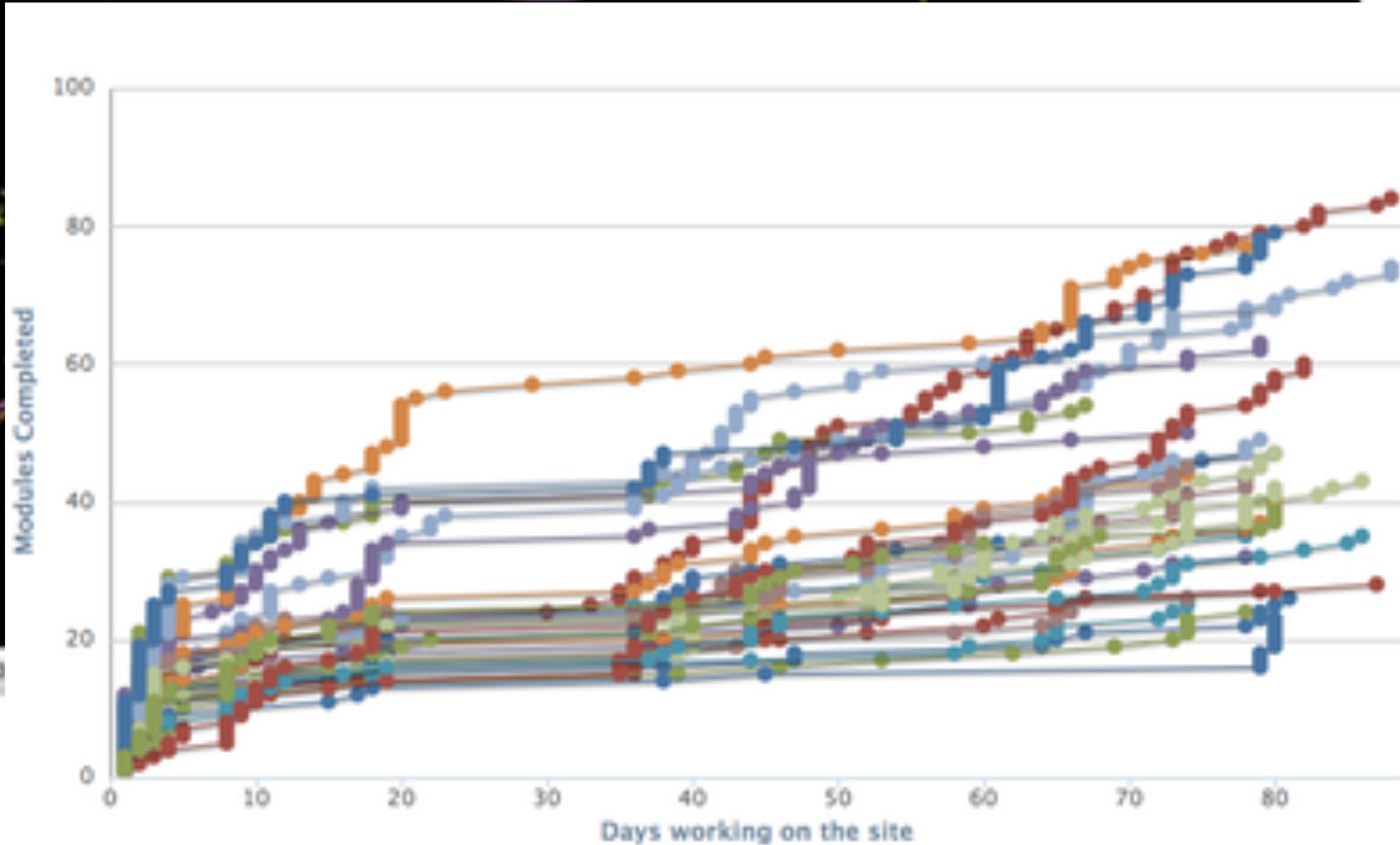
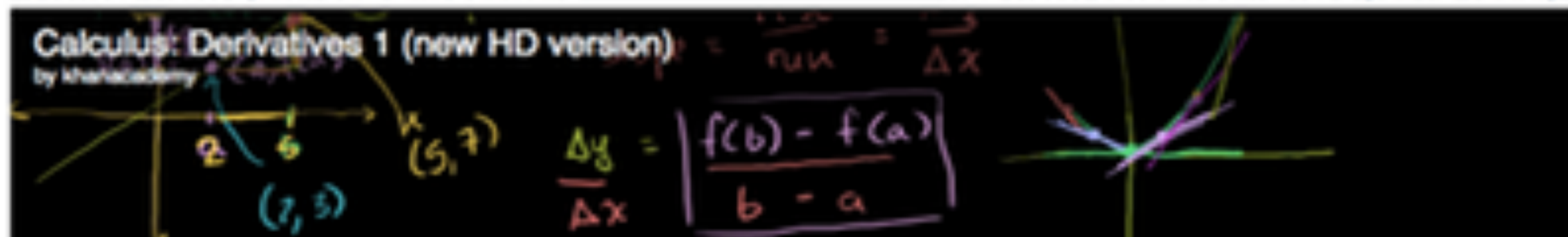
Video player controls: 10:53 / 15:43, 720p



**KHAN**  
ACADEMY

[Previous Video: Epsilon Delta Limit Definition 2](#)

[Next Video: Calculus: Derivatives 2 \(new HD version\)](#)



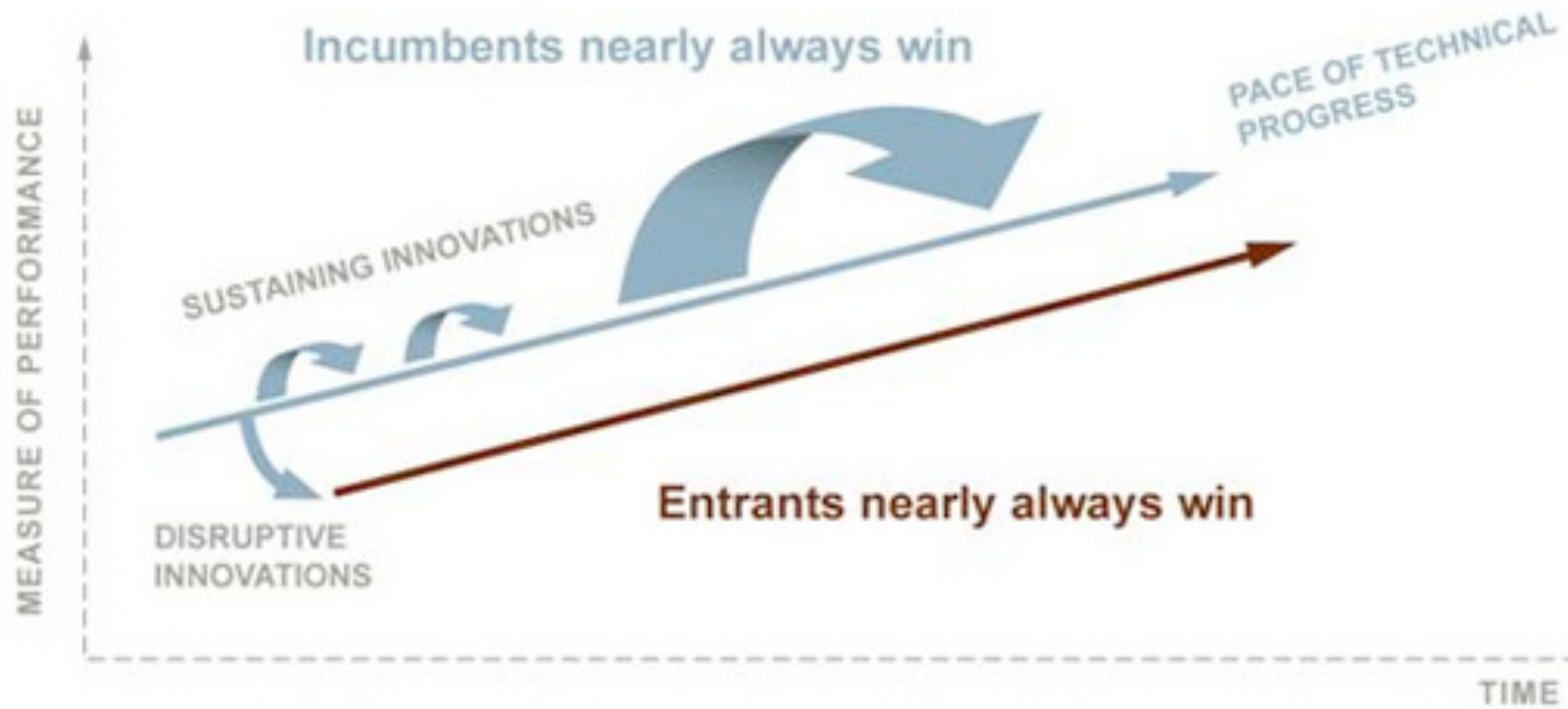


# Schema

Children try to manipulate every screen of any type as if it were a multi-touch display, like the iPhone.

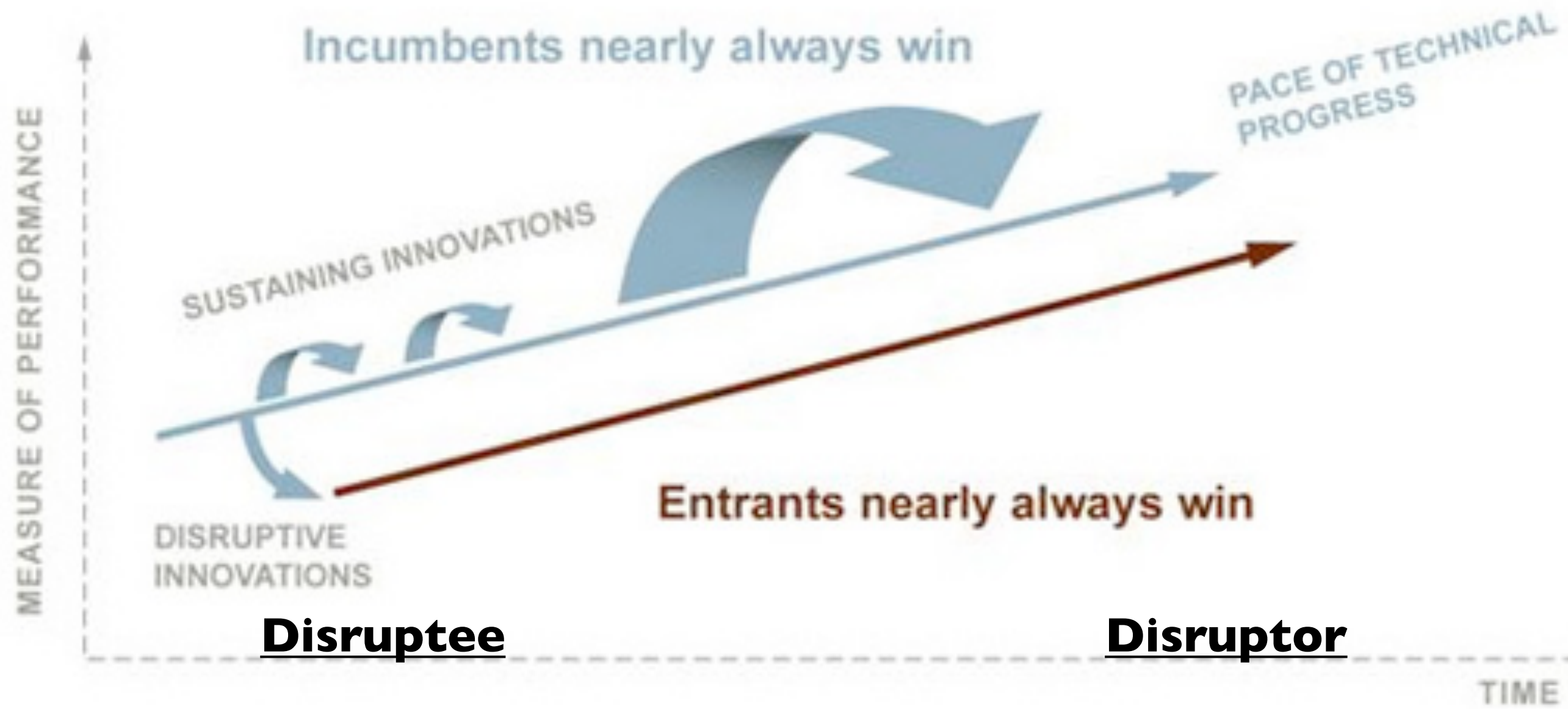
TVs, computers, laptops, even magazines.





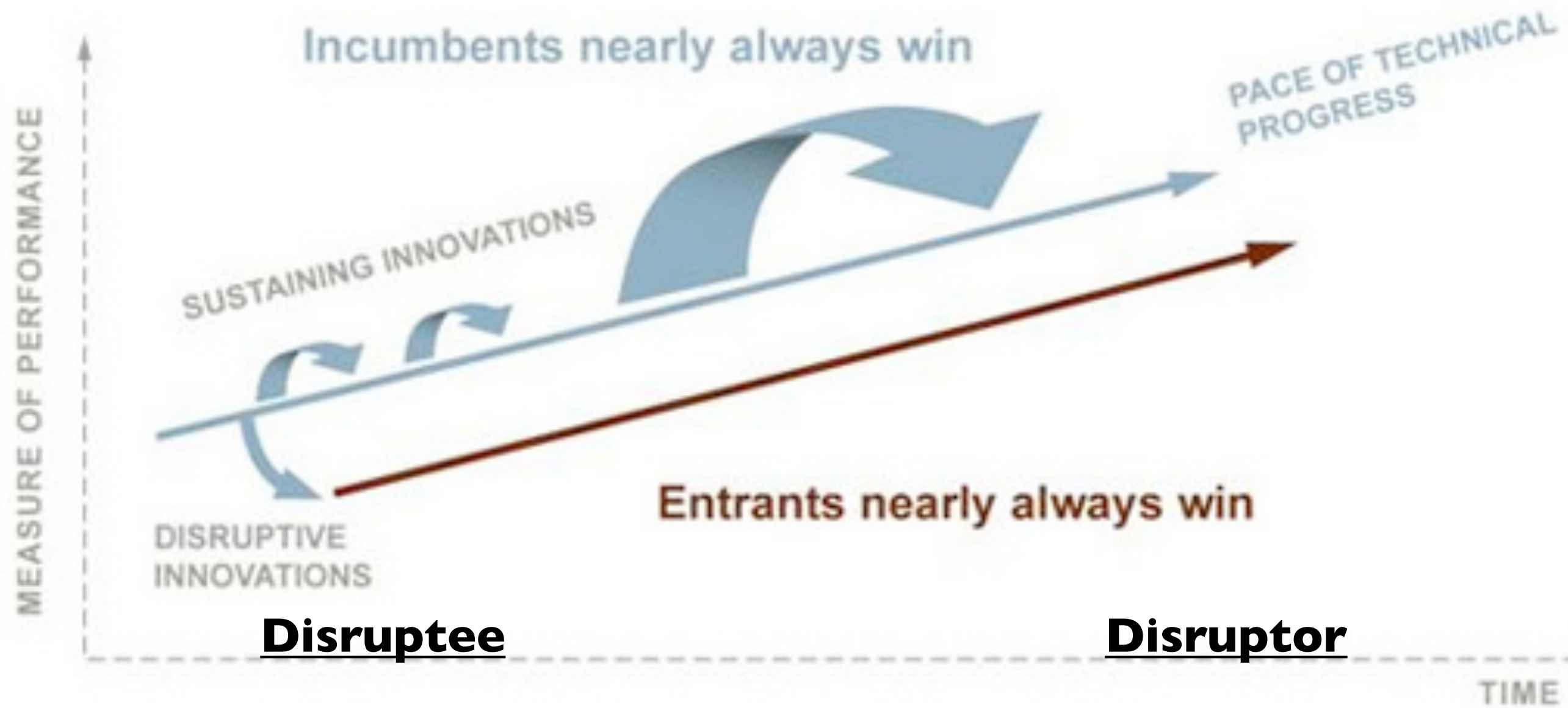
Source: Clayton Christensen



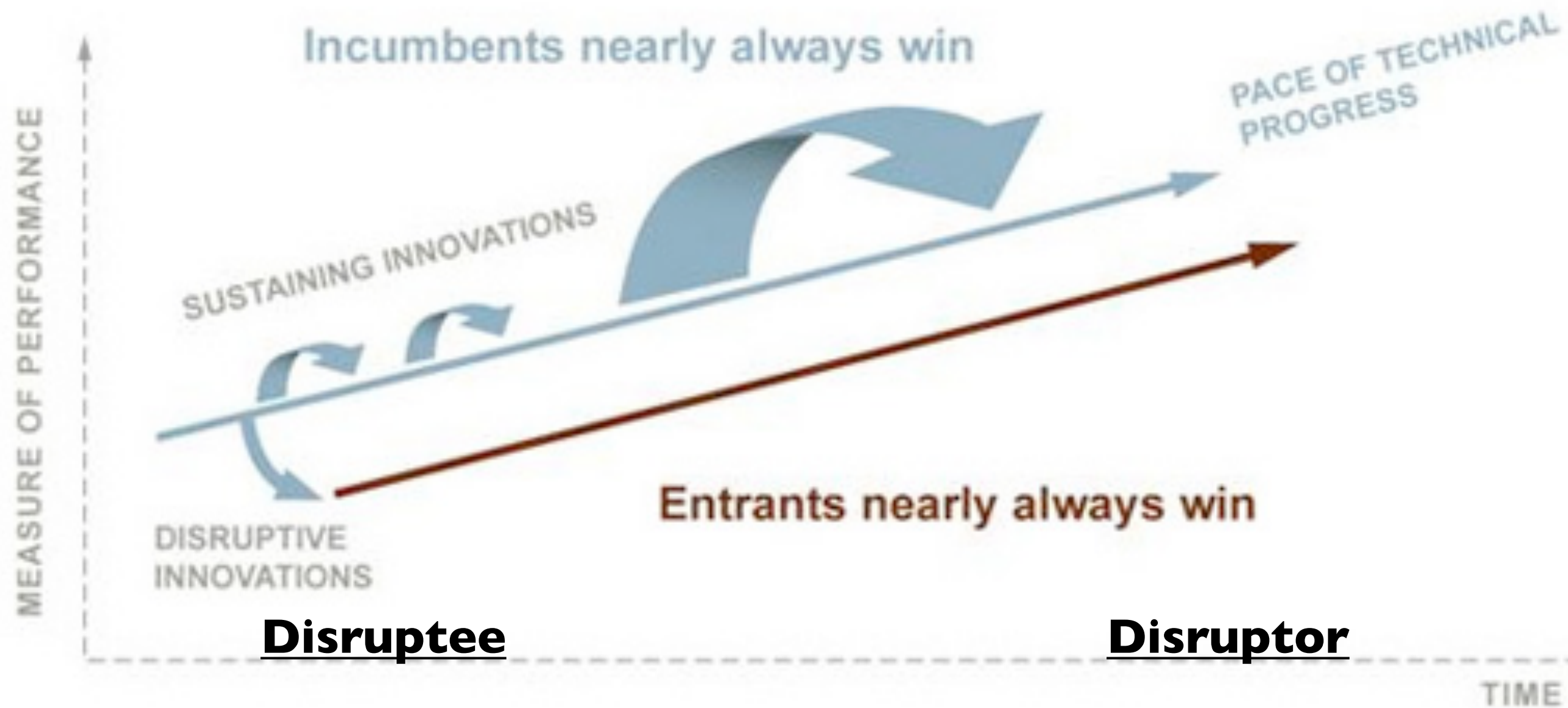


Source: Clayton Christensen





Source: Clayton Christensen



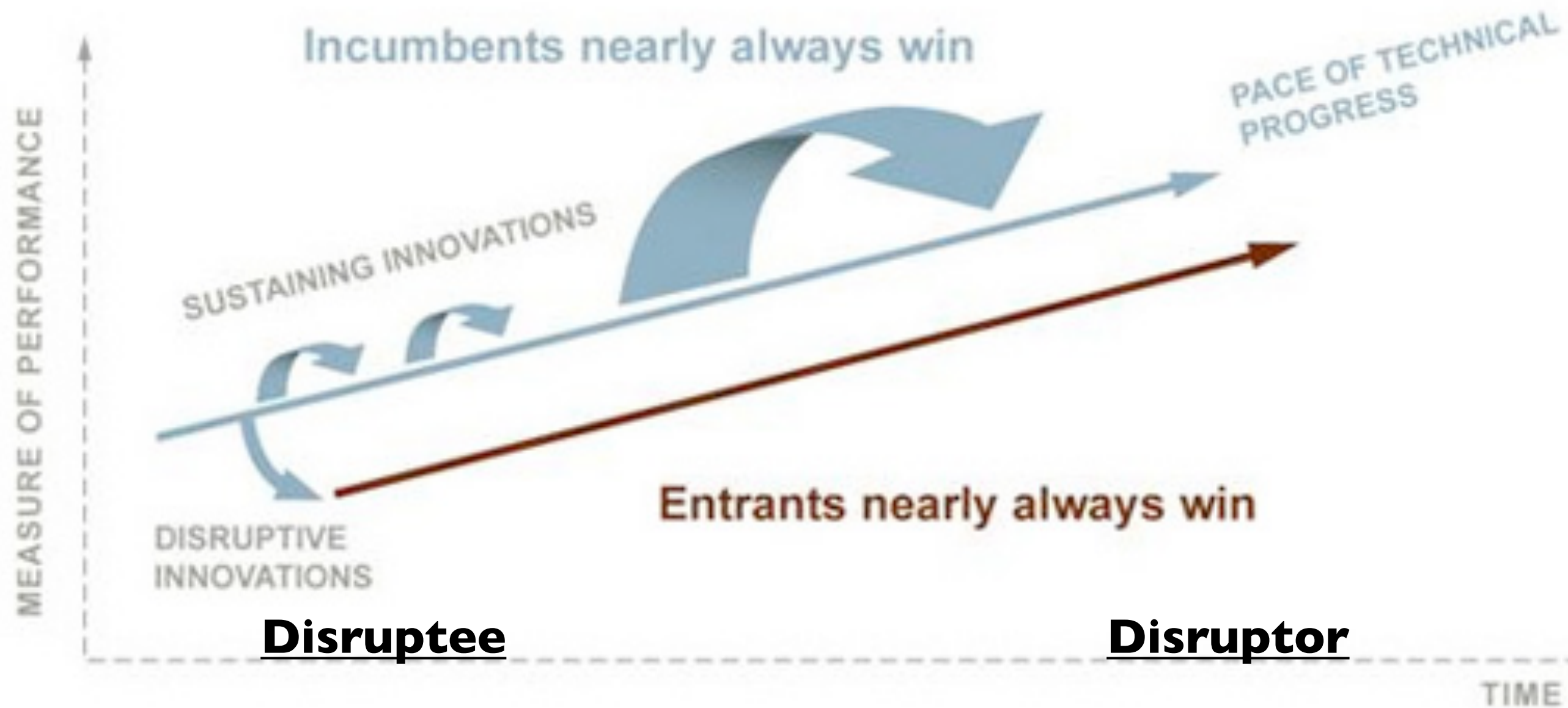
Source: Clayton Christensen

Fixed line telephony

Mobile phones

Full service department stores

Discount retailers



Source: Clayton Christensen

Fixed line telephony

Mobile phones

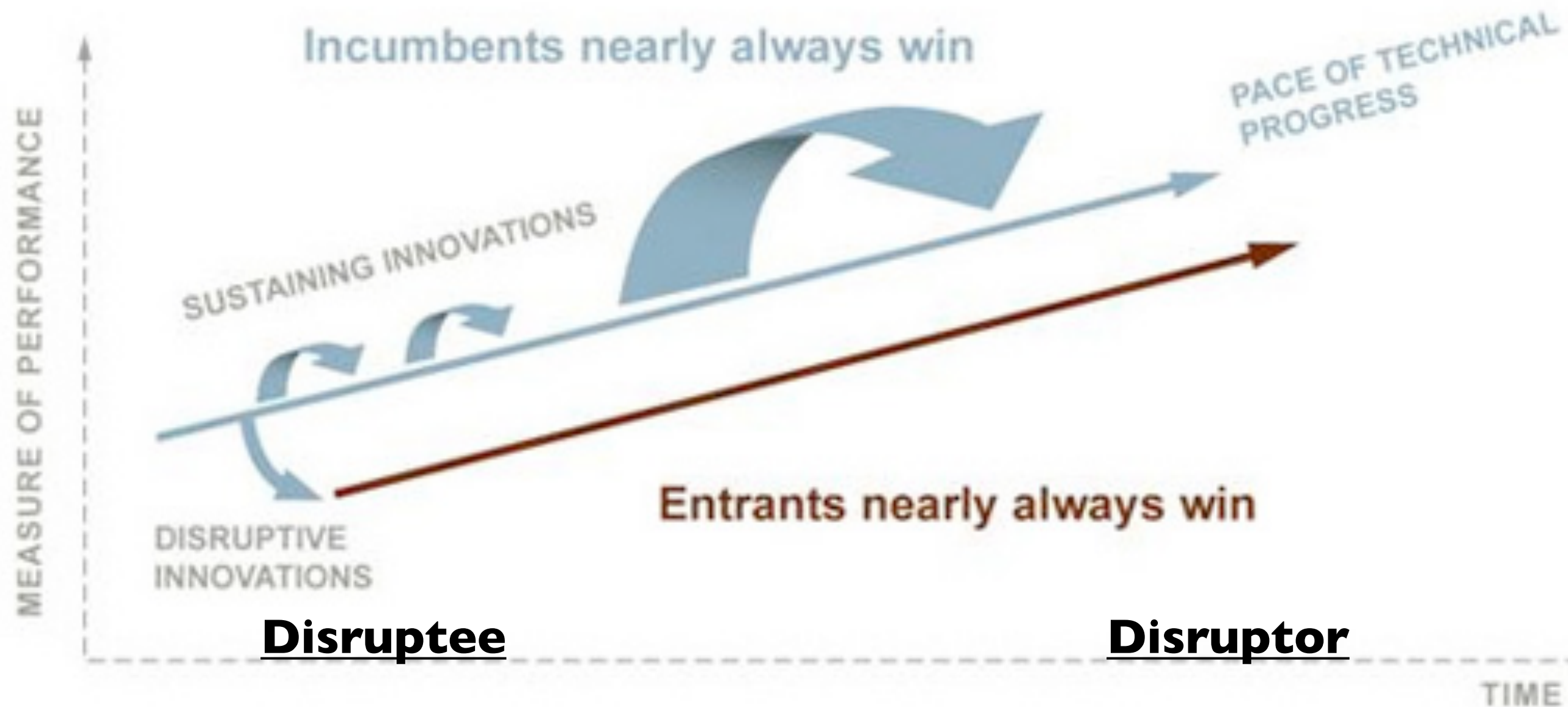
Full service department stores

Discount retailers

Traditional doctors office

Retail clinics





Source: Clayton Christensen

Fixed line telephony

Full service department stores

Traditional doctors office

Four-year colleges

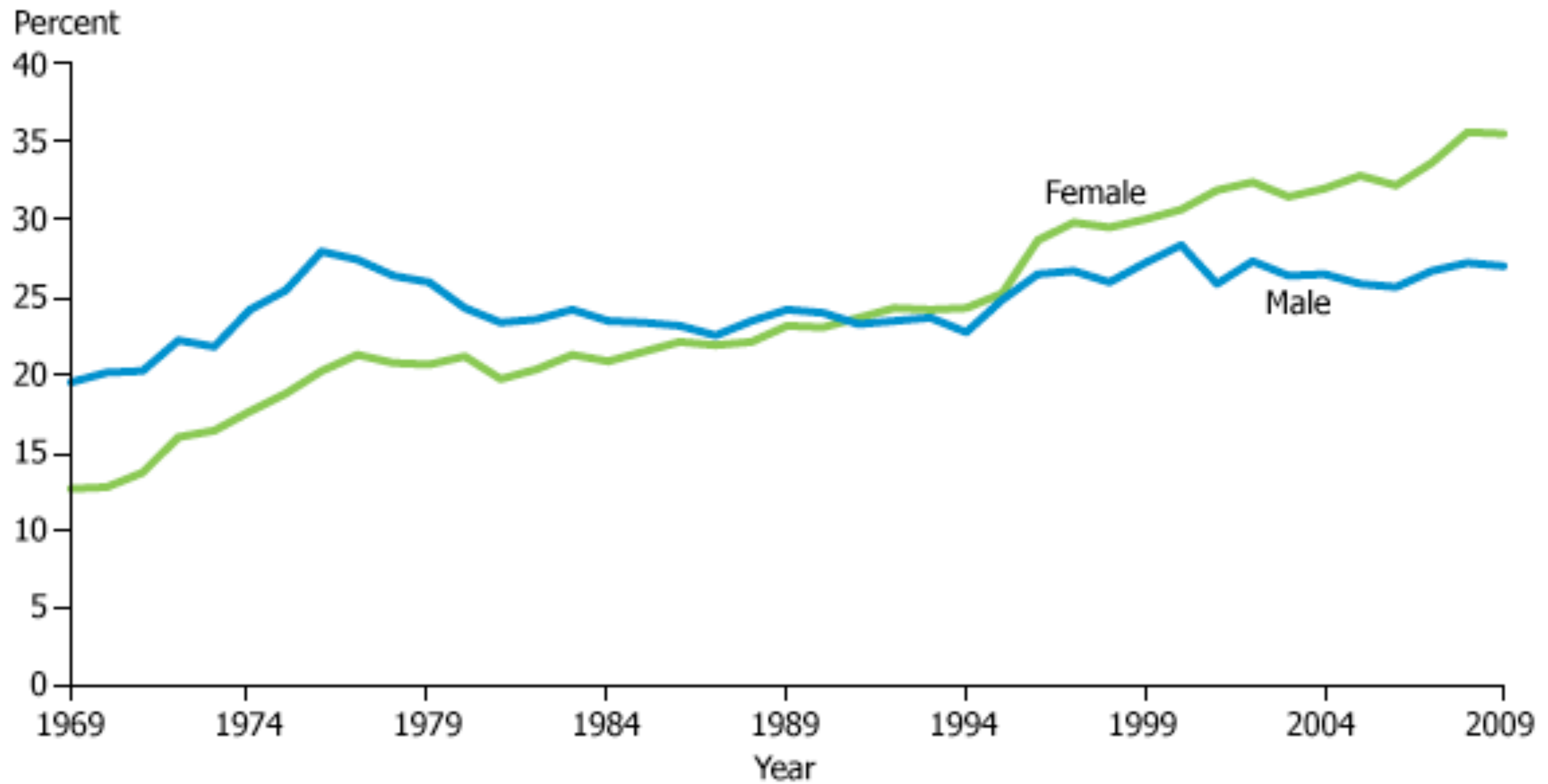
Mobile phones

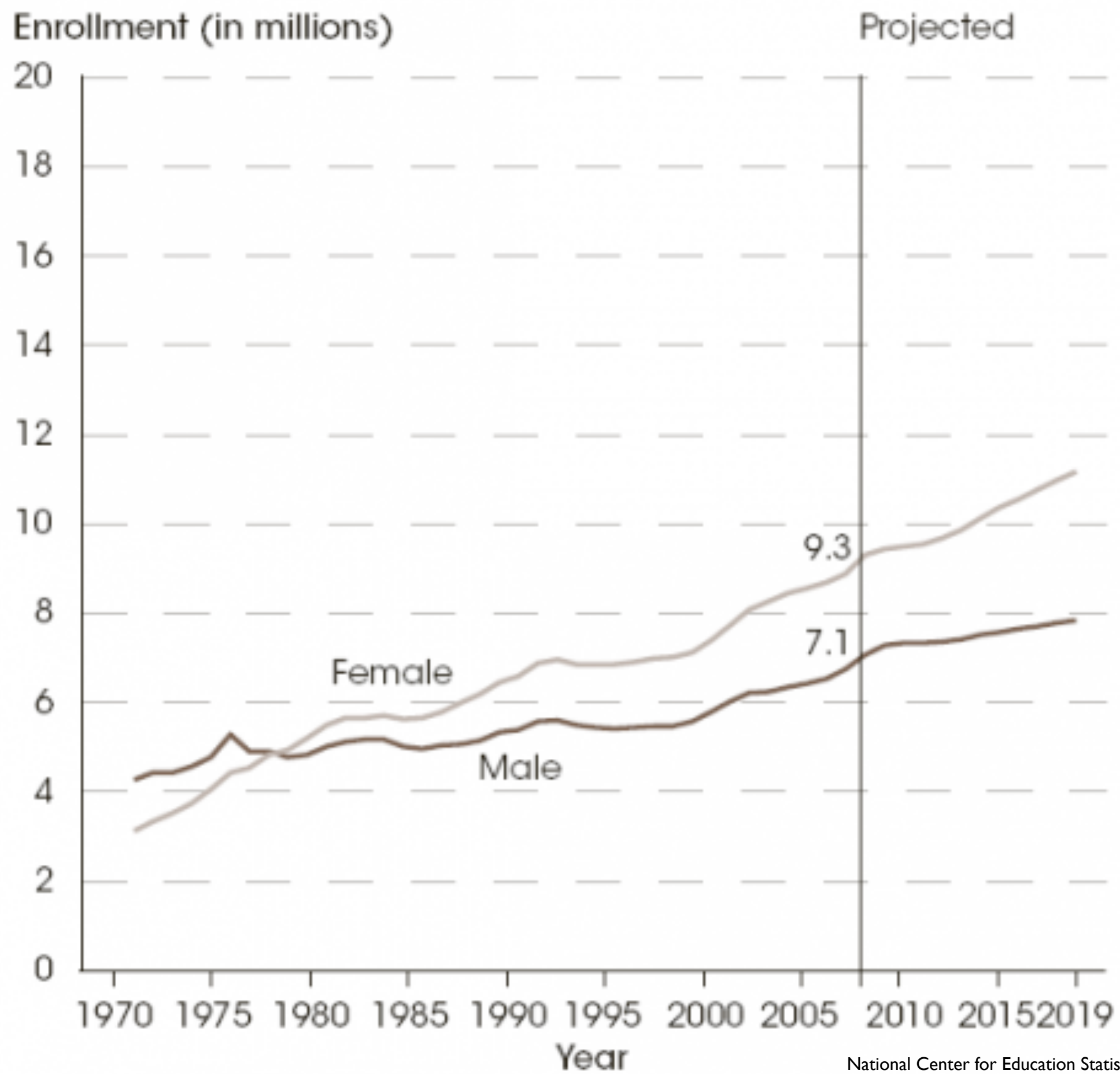
Discount retailers

Retail clinics

Community colleges

Percent of U.S. Adults Ages 25-29 With a Bachelor's Degree or Higher, 1969-2009

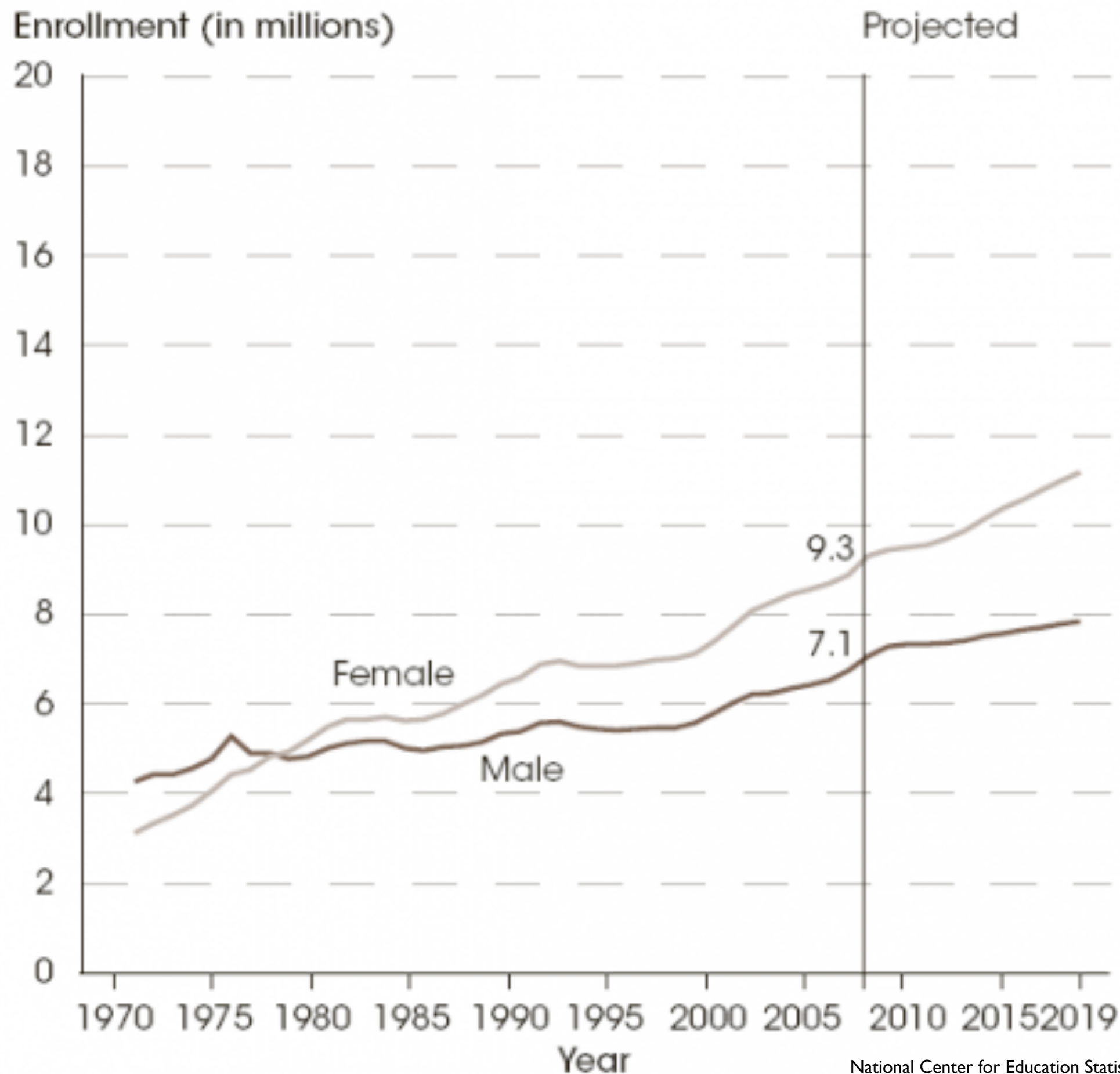




National Center for Education Statistics

Hooray for girls!





Hooray for girls!

—

What's going on with boys?

Not preparing boys well?

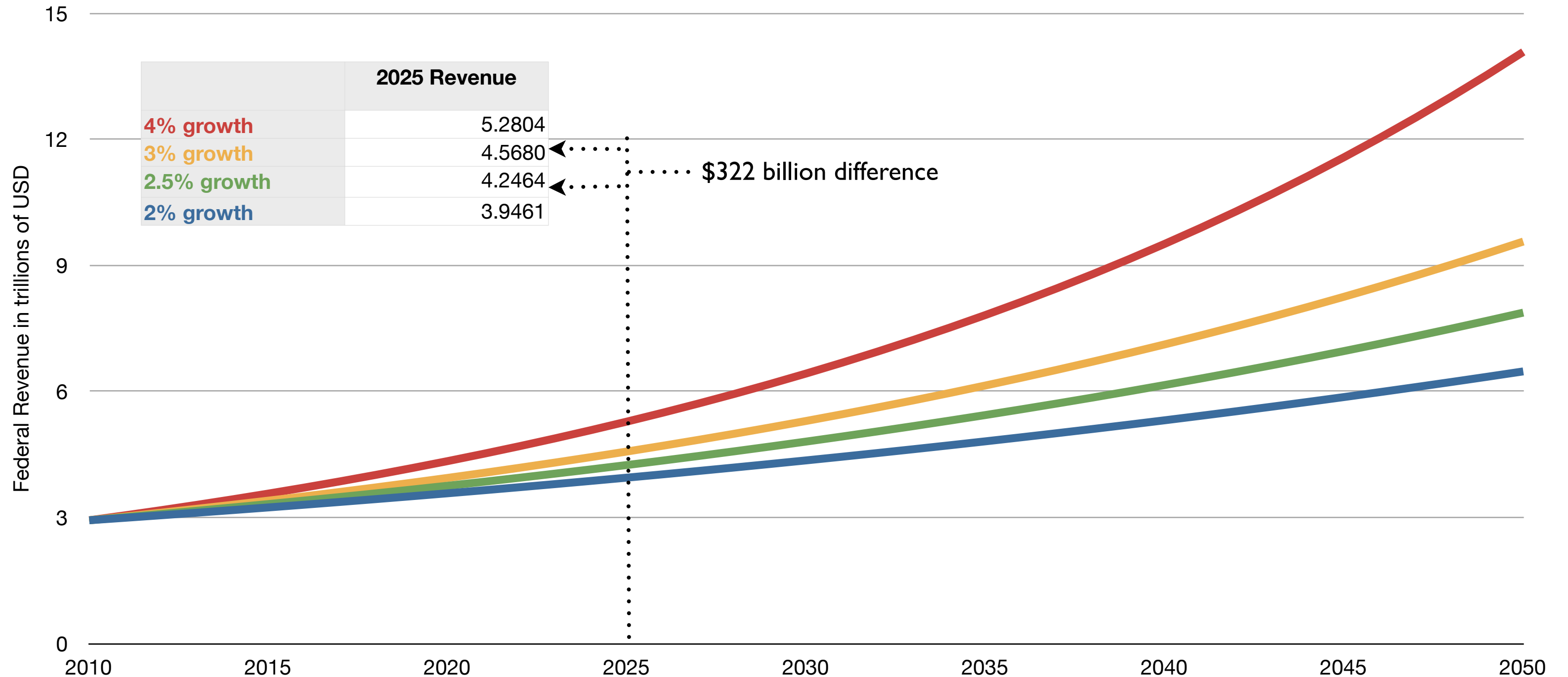
Not seeing value in college? Simply  
responding to the market?

Cultural problem?

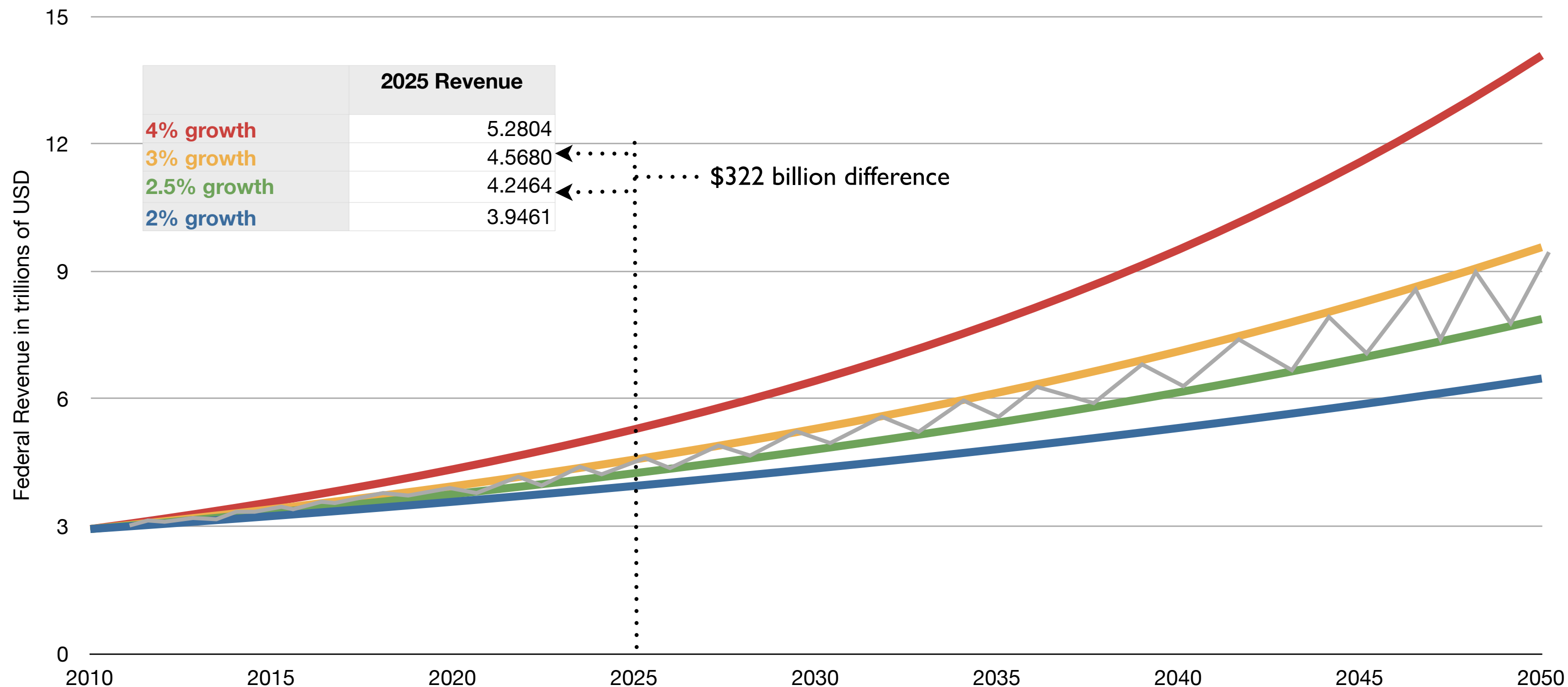
Or are boys a leading indicator of a  
Higher Ed Bubble?

Are too many girls going to college?

# Revenue Scenarios with 20% tax/GDP ratio

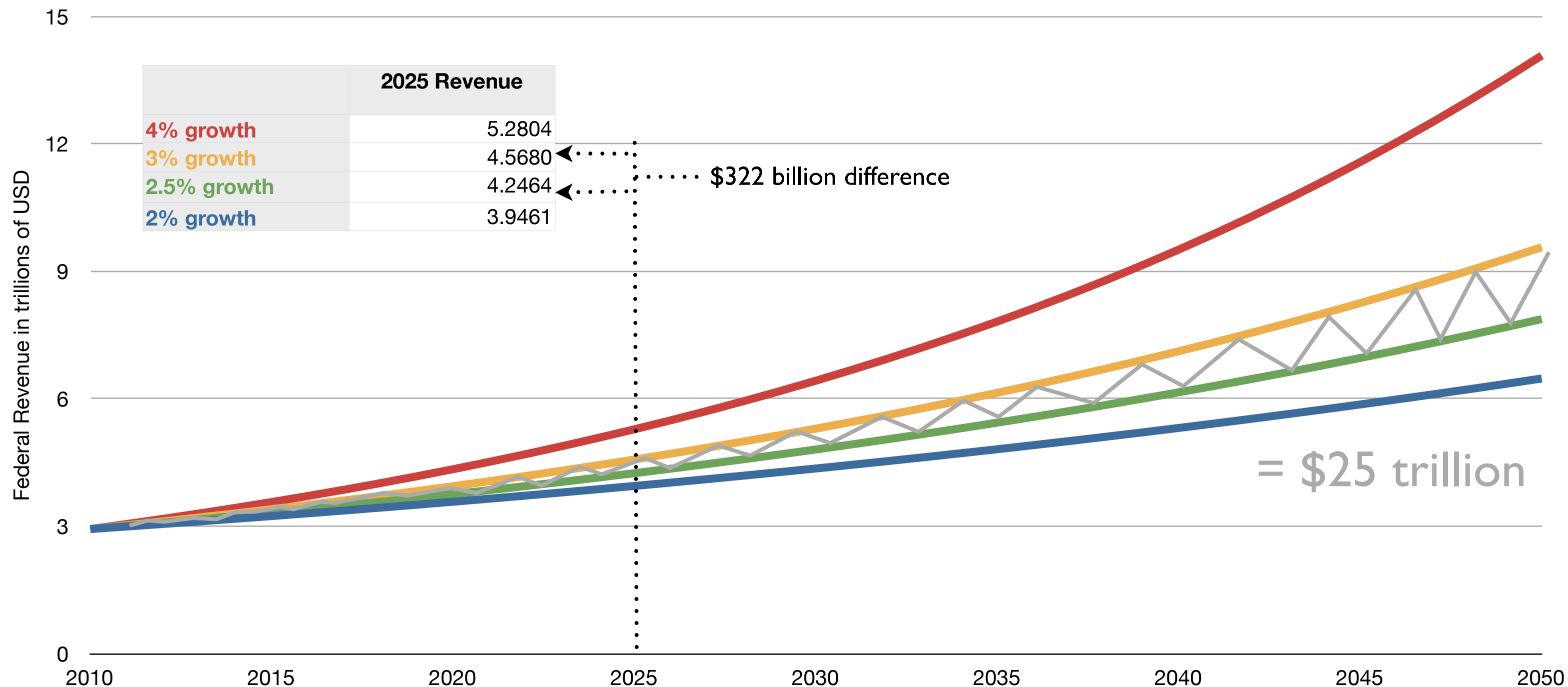


# Revenue Scenarios with 20% tax/GDP ratio





# Revenue Scenarios with 20% tax/GDP ratio





# Thank you.

EduComm  
15 June 2011  
Orlando

Bret Swanson  
[entropyeconomics.com](http://entropyeconomics.com) | [bretswanson.com](http://bretswanson.com)