Innovation
UTM Lecture I

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What is innovation?

- The introduction of something new
- In economics:
  - A new good or service (hopefully, better than existing ones), a new process to produce them, new business plans, or management practices.

How does innovation take place?

- Exogenously: Serendipitous discovery of the innovation without any need to invest resources
- Endogenous: Somebody invests resources (labor, capital, output,…) to come out with an idea and develop into a prototype.
  - The endogeneity of technology implies that there is an innovation production function:
  - Innovation = R&D product* R&D investments
  - How can we increase the rate of innovation?

Why do we care about innovation

- Role of innovation on long-run productivity growth
- Innovation and firm volatility
- Innovation and the business cycle

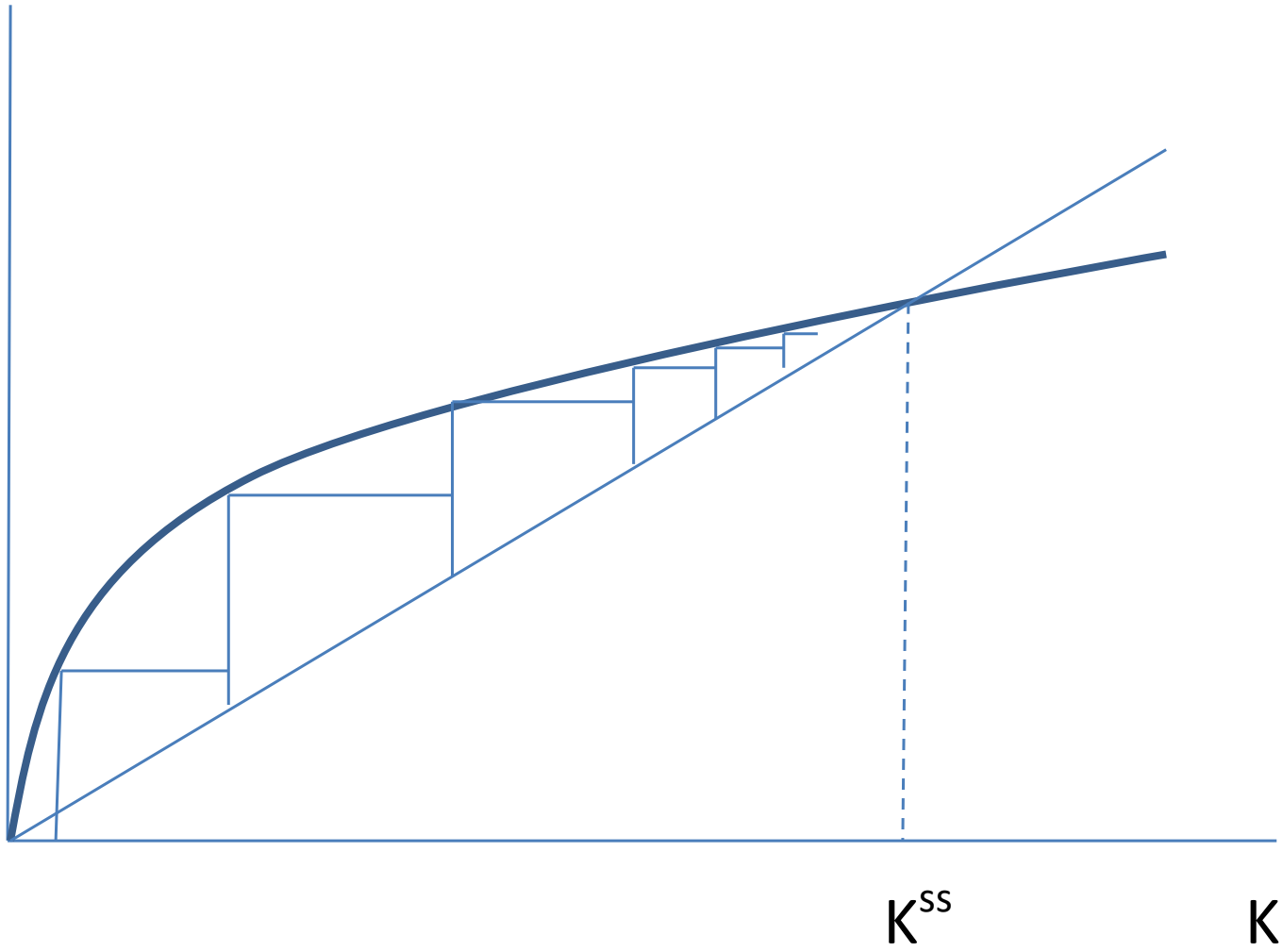
The organization of innovation

- What role should the government play in R&D policy?
- Why should R&D be subsidized?
- Should the government be directly involved in conducting R&D activities?

INNOVATION AND LONG-RUN GROWTH

Investment and long-run growth

- Can a country grow in the long-term just by investing?
- NO
- GDP=F(K,L,A)
- Gross Savings= s*F(K,L,A)
- Depreciation = δ*K
- ΔK = s*F(K,L,A)- δ*K


K^{SS}
K

Lessons

- When there are diminishing returns to K…
- … to improve productivity (Y/L) in the long term, it is necessary that A increases.
- Adding investment without bringing new technology, eventually, does not generate growth

Implications for NEM

- NEM emphasizes increasing GDP by raising investment (mostly public investment)
- This may work in the short term
- But it does not lead to sustained growth in the long term
- Low investment is an indicator of deeper problems

Innovation and Long-run Growth

- To generate growth in the long term, countries need to increase their technology continuously

Technology for companies

- Companies can improve their technology in three distinct ways:
  - Innovating: coming up with new ideas and implementing them into new products or processes
  - Adopting existing technologies
  - Using more intensively technologies that the company has already started to adopt in the past.

Technology for countries

- The same logic goes through
- Productivity/technology can improve by
  - Developing new technologies (innovation)
  - Bringing in new technologies invented by somebody else
  - Using more intensively technologies that have adopted in the past

What strategy should a country like Malaysia follow?

- In areas where the company/country is close to the frontier technology, the only way to improve productivity is to innovate. (e.g., palm oil)
- In areas where the country is far from the frontier, there is much to gain by just adopting frontier technology. (e.g., electronics, car manufacturing,…)
- Later (and tomorrow) we'll discuss how to do that

INNOVATION AND TURBULENCE

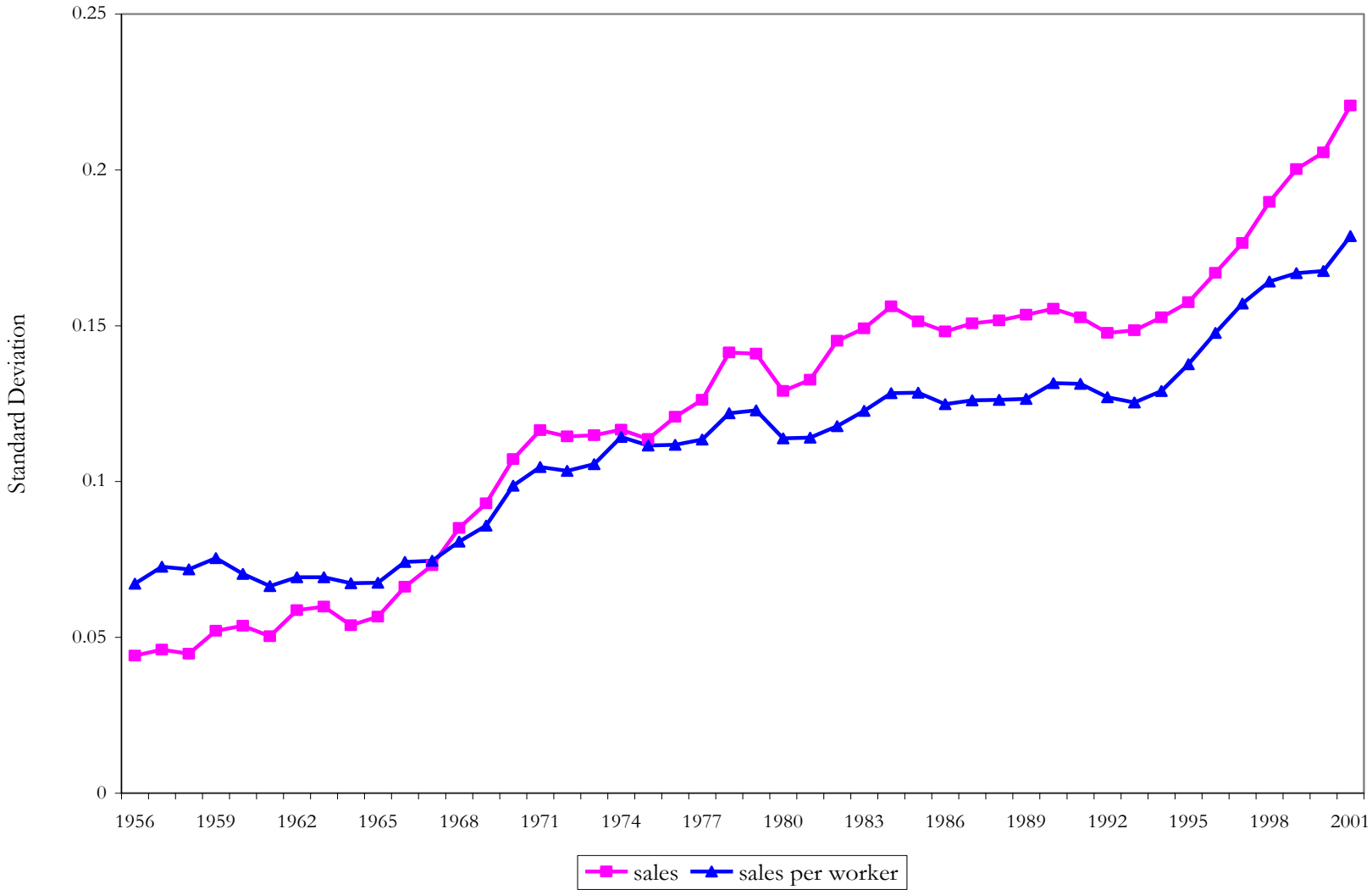
Firm Volatility

- Importance of stability of business environment for firm performance
- How do we measure the stability of the business environment?
- Has the business environment become more/less volatile?
- What factors affect firm volatility?

Measurement

- How to measure firm volatility?
- Two steps
- 1. Compute annual growth rate of sales, sales per worker, employment, return,… at the firm level
- 2. Compute standard deviation of consecutive growth rates in a rolling window of 5 or 10 years.

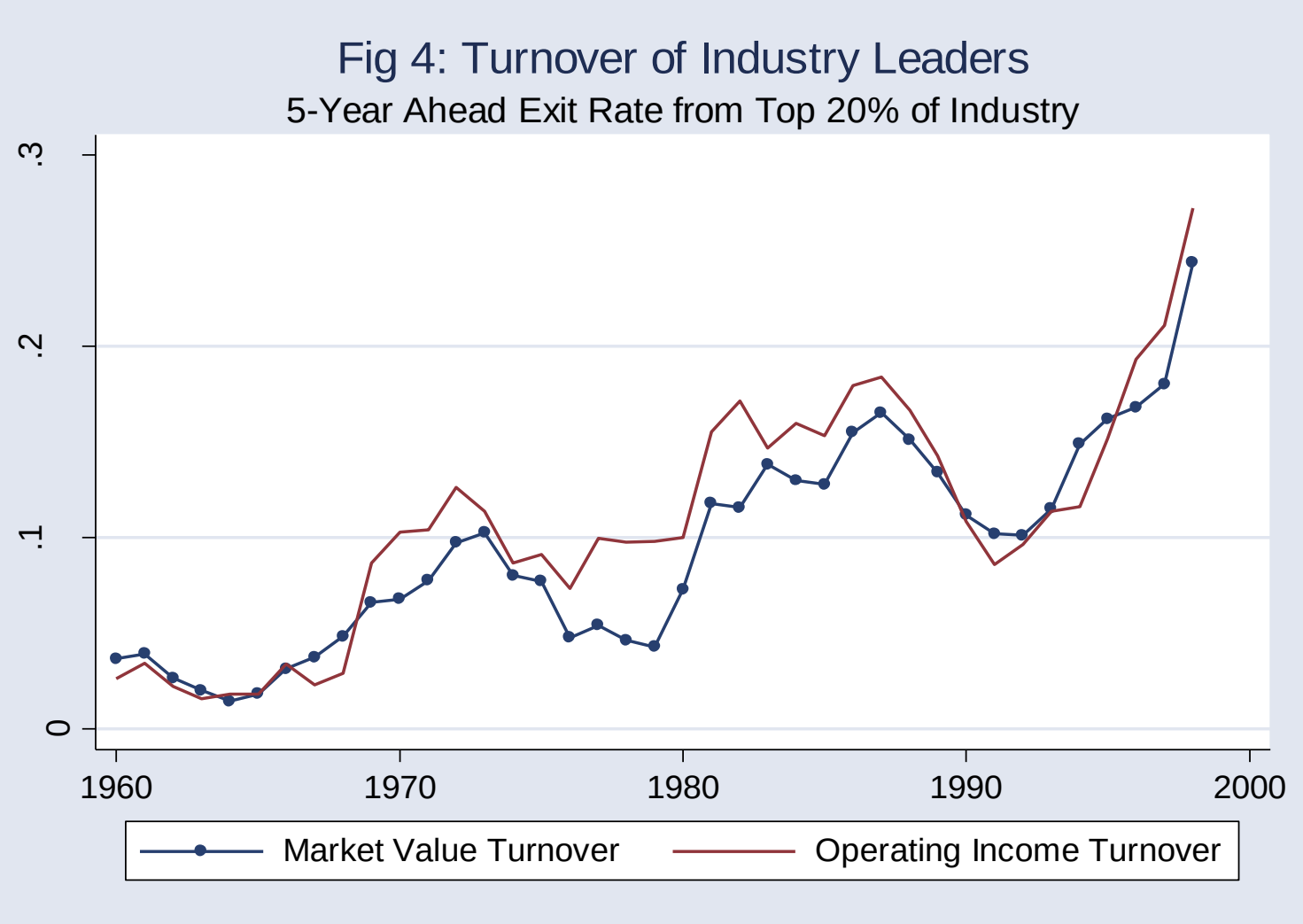
Firm Volatility



Non-drivers of firm volatility

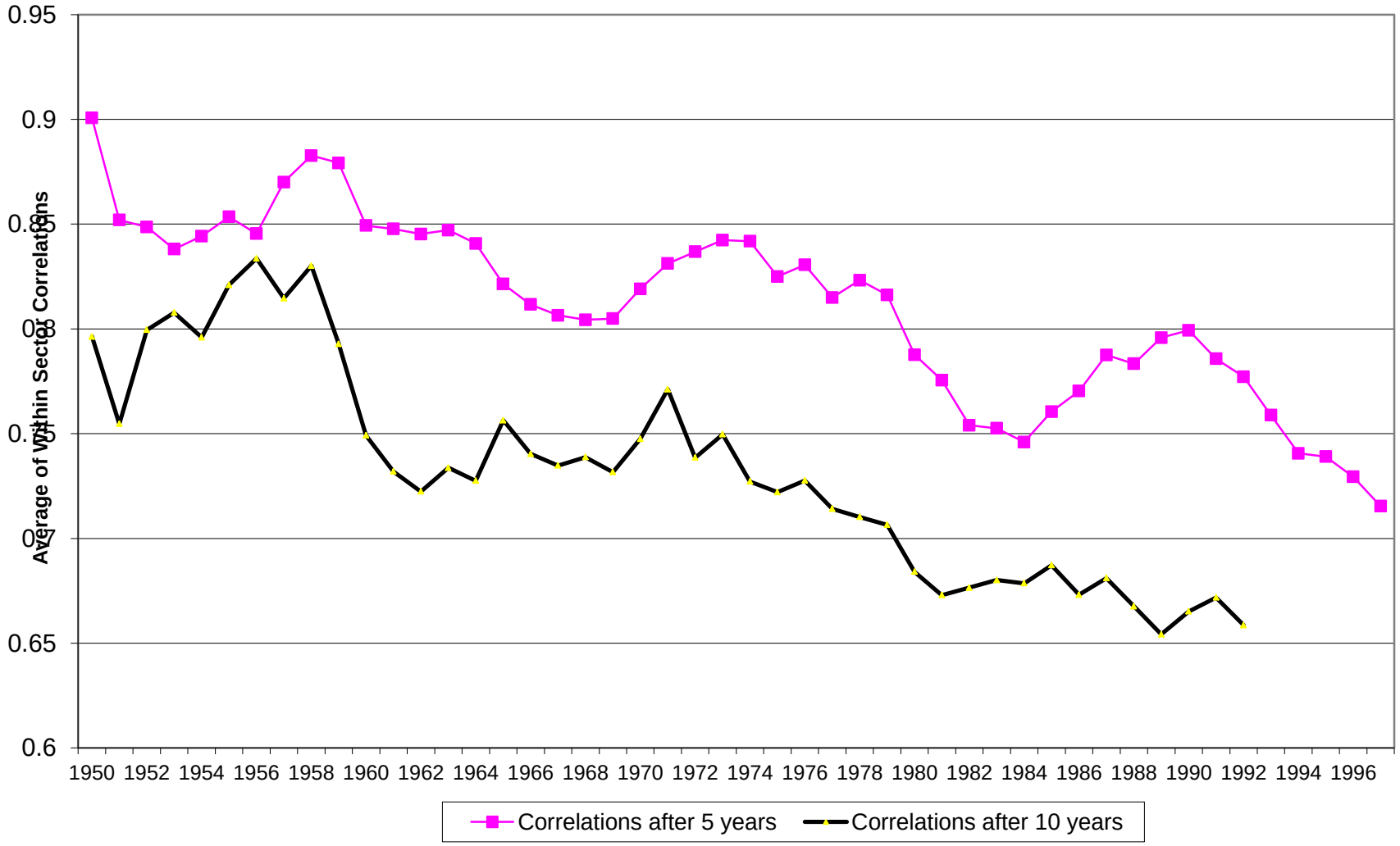
- 1. Change in composition of companies (more young firms, small firms)
- 2. Faster incorporation of companies
- 3. Changes in the sectoral composition of publicly traded companies
- 4. More mergers
- 5. aggregate volatility

Greater instability of market leadership



Alternative measures of instability

Fig5 : Correlation of Labor Productivity Rankings



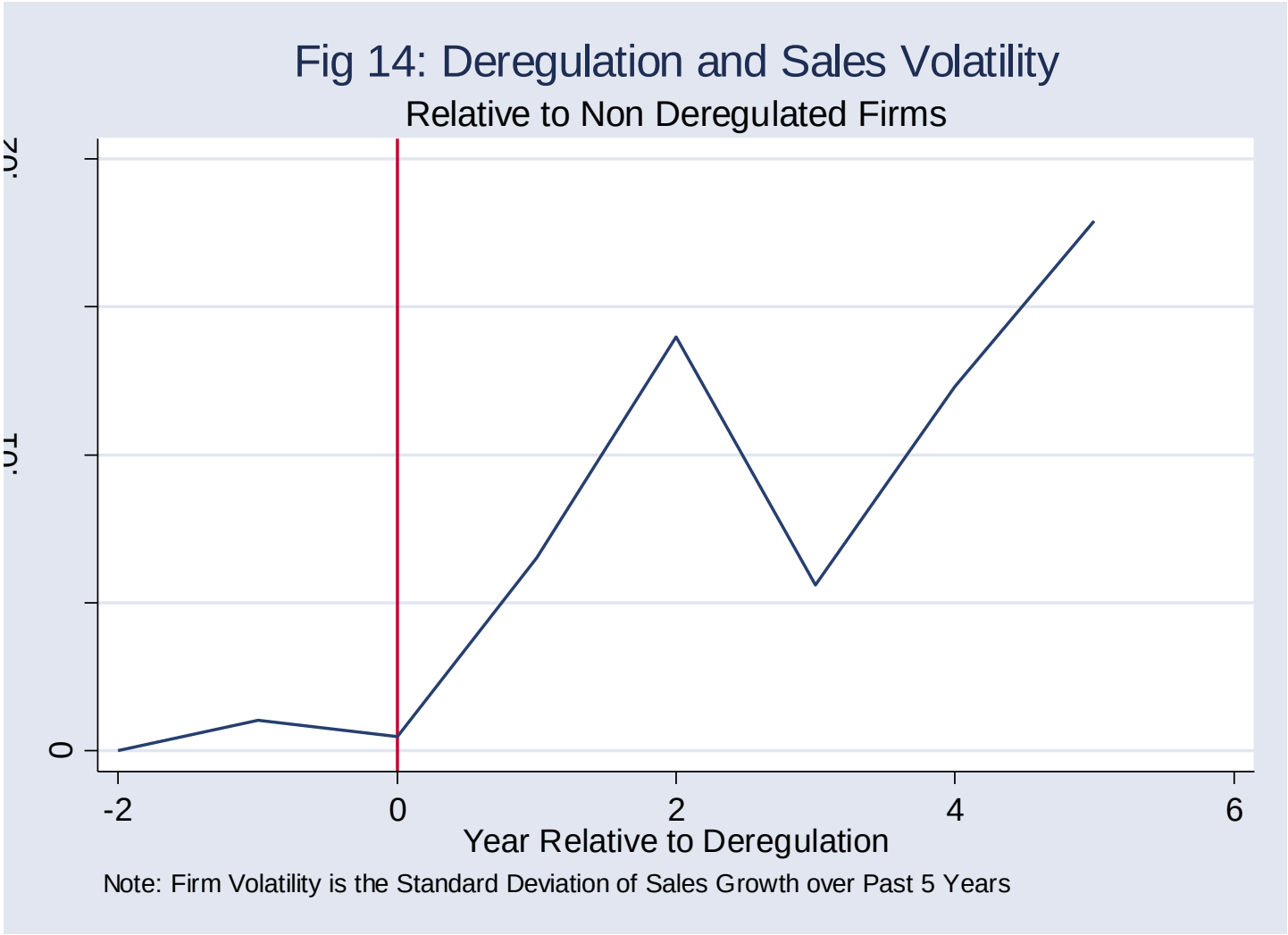
Possible Drivers

- Globalization
- Deregulation
- Financial liberalization
- Innovation

Globalization

- Why could it matter?
- In a globalized world, companies compete with foreign competitors in addition to domestic ones
- This creates both opportunities and challenges. Hence, higher volatility.
- Increase in firm volatility both in tradable and in non-tradable sector
- Increase in volatility of productivity similar to increase in volatility of sales.

Deregulation



Financial development and volatility

- Firms can take greater risks because they can finance more risky projects
- Firms that engage in risky projects reach higher sales if successful but experience greater losses if unsuccessful
- Evidence: Ratio of equity and debt is positively correlated with firm volatility

R&D and firm volatility

Table 4: R&D and Firm Volatility, Panel Regression, 1956-1997, 35 sectors

	Dependent Variable			
	Mean Volatility of Sales	Mean Volatility of Sales per Worker	Median Volatility of Sales	Median Volatility of Sales per Worker
R&D/Sales	3	2.88	0.65	0.49
	(0.93)	(0.83)	(0.29)	(0.21)
N	1260	1258	1260	1258

Newey-West Standard errors in parenthesis

All regressions include a time trend and sector dummies.

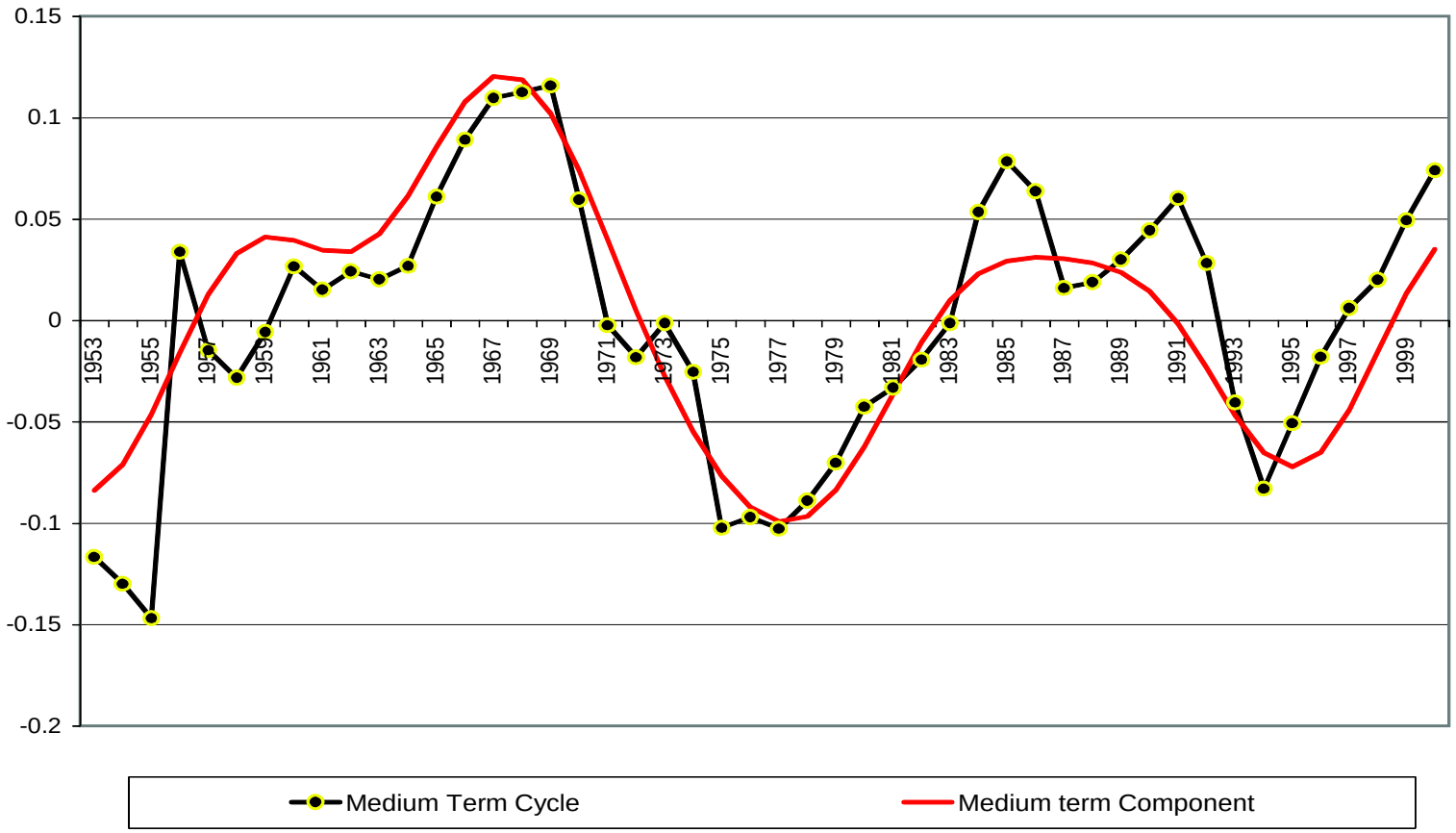
How do firms cope with higher volatility?

- Pass part of the volatility to workers in the form of more volatile wages and part to the shareholders in the form of more volatile dividends
- As a result, wages and dividends have also become more volatile

INNOVATION AND BUSINESS CYCLES

Innovation and the business cycle

- Are (real) R&D expenditures cyclical?



R&D and the cycle

- R&D is very volatile (twice as much as output)
- R&D is positively correlated with aggregate demand
- The speed of technology adoption is also highly pro-cyclical (the elasticity wrt GDP is 5)

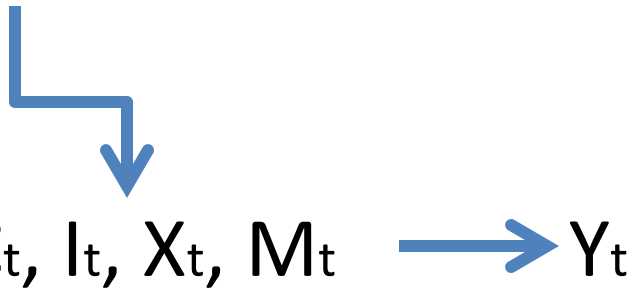
Evidence

Table 2B: R&D expenditures and sectoral demand								
	Real Value Added Growth in 3 digit				Real Gross Output Growth in 3 digit			
	I	II	III	IV	V	VI	VII	VII
Sectoral demand growth	0.187*** (0.03)	0.094*** (0.012)	0.077** (0.035)	0.053*** (0.013)	0.58** (0.055)	0.447*** (0.028)	0.19** (0.089)	0.365*** (0.043)
Current Cashflows	0.006*** (0.002)	0.0016*** (0.0003)	0.005*** (0.002)	0.0014*** (0.0004)	0.005** (0.0019)	0.0013*** (0.0003)	0.005*** (0.0019)	0.0015*** (0.0004)
Lagged Cashflows	0.005*** (0.002)	0.0046*** (0.0003)	0.003* (0.0017)	0.004*** (0.0003)	0.004** (0.0017)	0.004*** (0.0003)	0.003* (0.0017)	0.037*** (0.0003)
N observations	11643	11643	11643	11643	11643	11643	11643	11643
N companies	3323	3323	3323	3323	3323	3323	3323	3323
Weighted	No	Yes	No	Yes	No	Yes	No	Yes
Year Dummies	No	No	Yes	Yes	No	No	Yes	Yes
All regressions include firm-fixed effects								

Why is R&D pro-cyclical?

- Demand: In times of larger demand increases the return to developing technologies, Schmookler (1966)
- Credit constrains: Companies are constrained in recessions to obtain the funds necessary to finance R&D activities

Why does it matter?

- The business cycle is the result of shocks that are amplified and propagated
- Temporary exogenous shocks (increases in oil prices, credit disruption, increases in labor income taxes,…)
- 

Why does it matter whether shock affects C or I ?

- How do we think about effects on Yt+1, Yt+2, Yt+3…
- Drop in I_t -> reduction in K_{t+1} -> affects future productivity
- Drop in R&D or in investments in technology upgrading -> decline in the level of technology-> affects future productivity

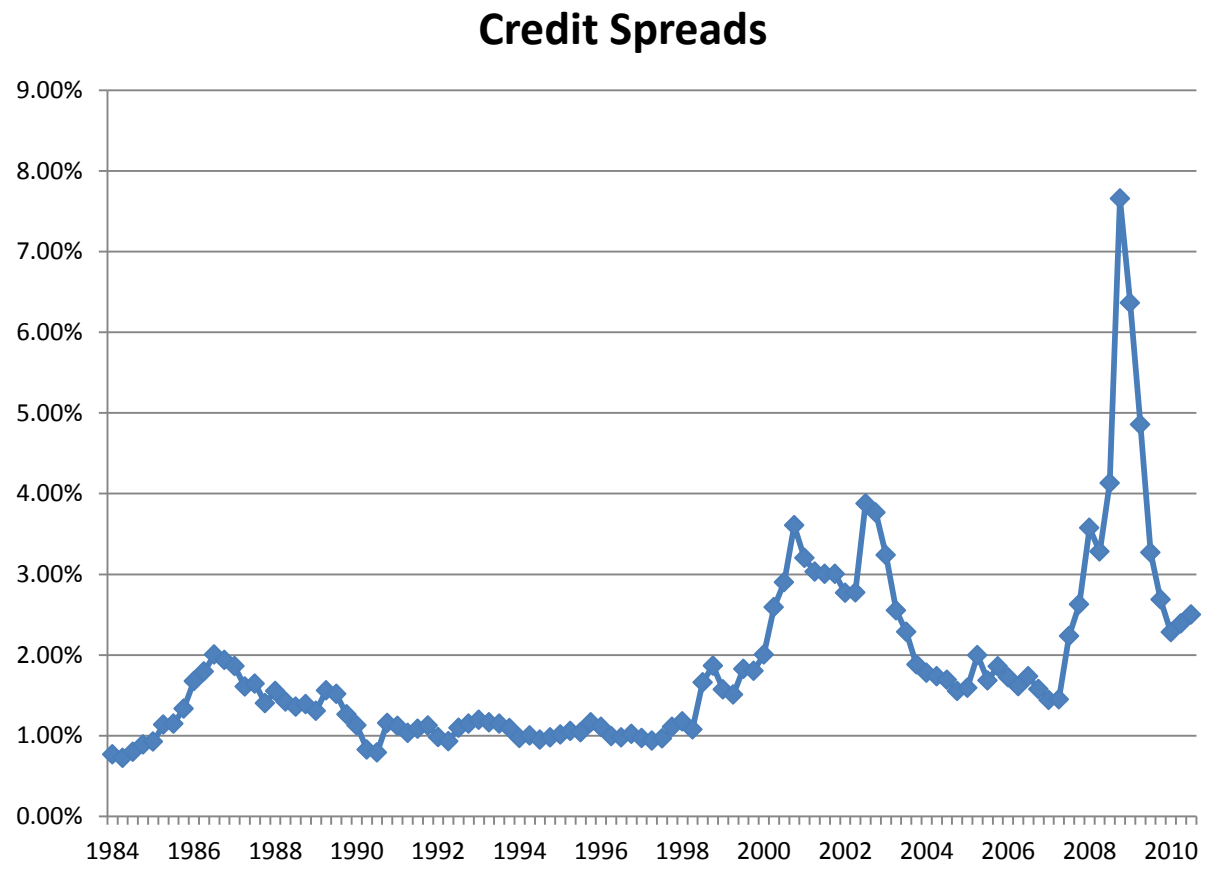
Why is this relevant?

- Why has the Great Recession lasted so long despite the brevity of credit markets disruption?
- In recessions, the return to developing and adopting new technologies drops.
- As a result, fewer technologies are developed
- And companies upgrade their technologies less frequently
- Causing a transitory drop in the growth rate of productivity ($\Delta A/A$)

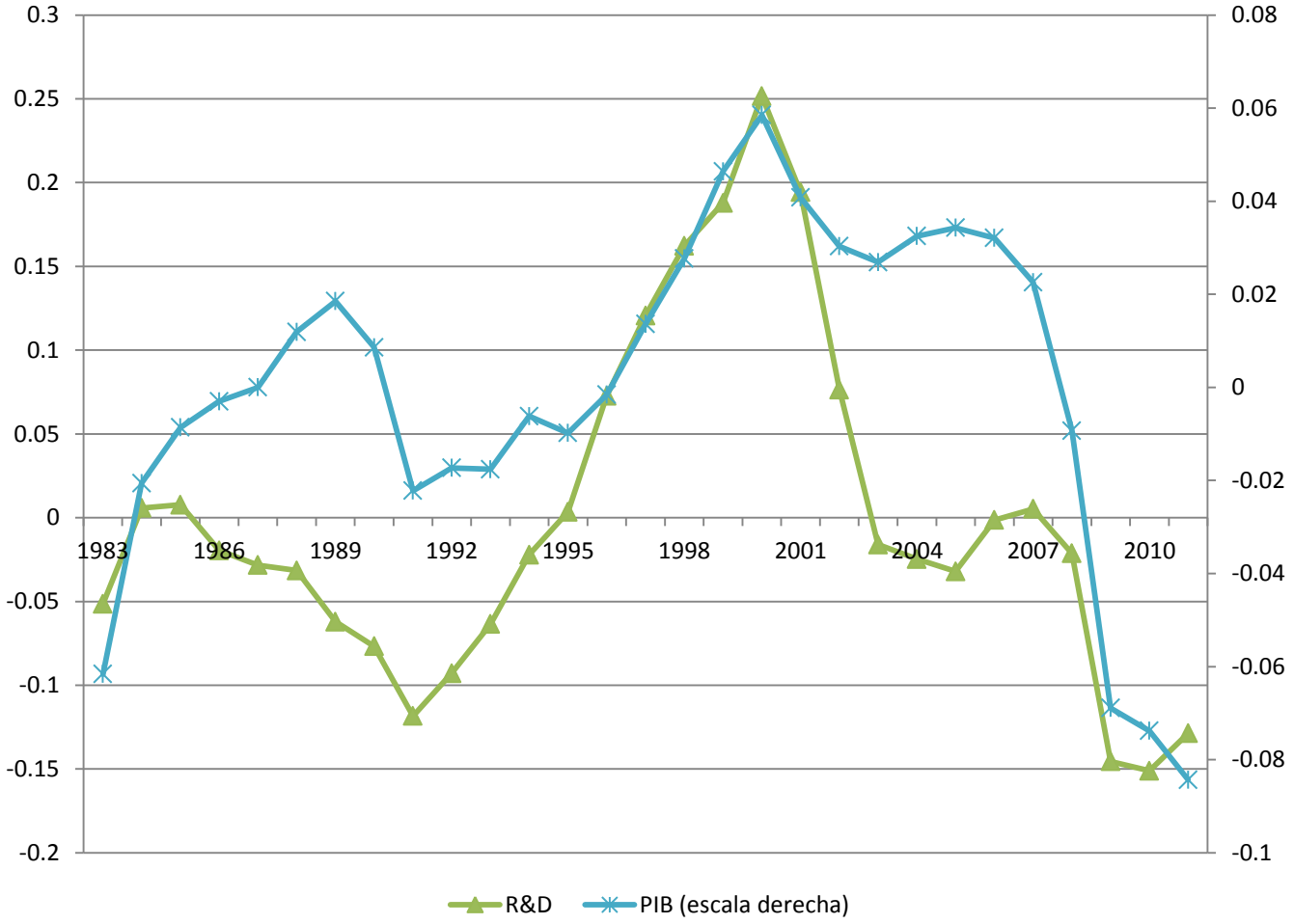
Cyclical effects

- Transitory growth rates of productivity lead to permanent declines in the level of productivity (A)
- As a result, once financial markets come back to the pre-recession level, the economy is less productive (relative to trend) than before, leading to a further drop in aggregate demand

Evidence


Credit Spreads
9.00%
8.00%
7.00%
6.00%
5.00%
4.00%
3.00%
2.00%
1.00%
0.00%
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010

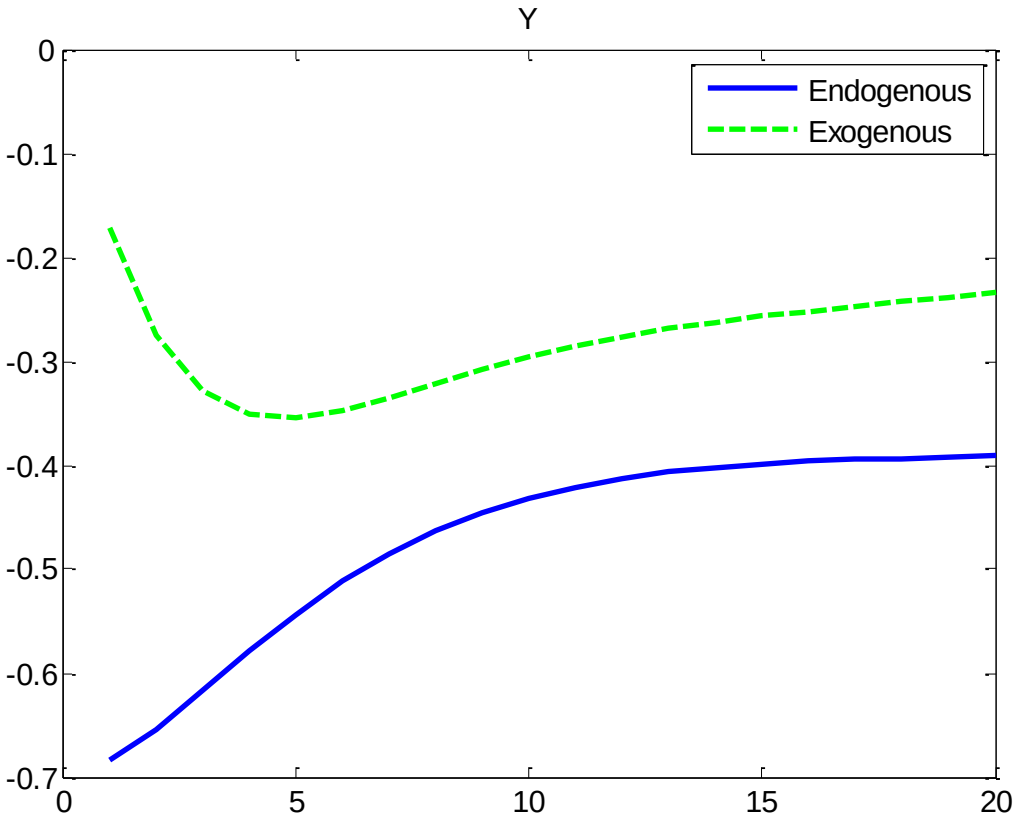
US GDP and R&D (detrended)



How do we study the effect of R&D on the persistence of shocks?

- Somewhat technical
- Several steps
- 1. build a macro model where firms have the option of investing in developing and adopting new technologies
  - The model also has monetary policy, price rigidities, … which make it realistic
- 2. Simulate the economy with and without endogenous technology mechanisms

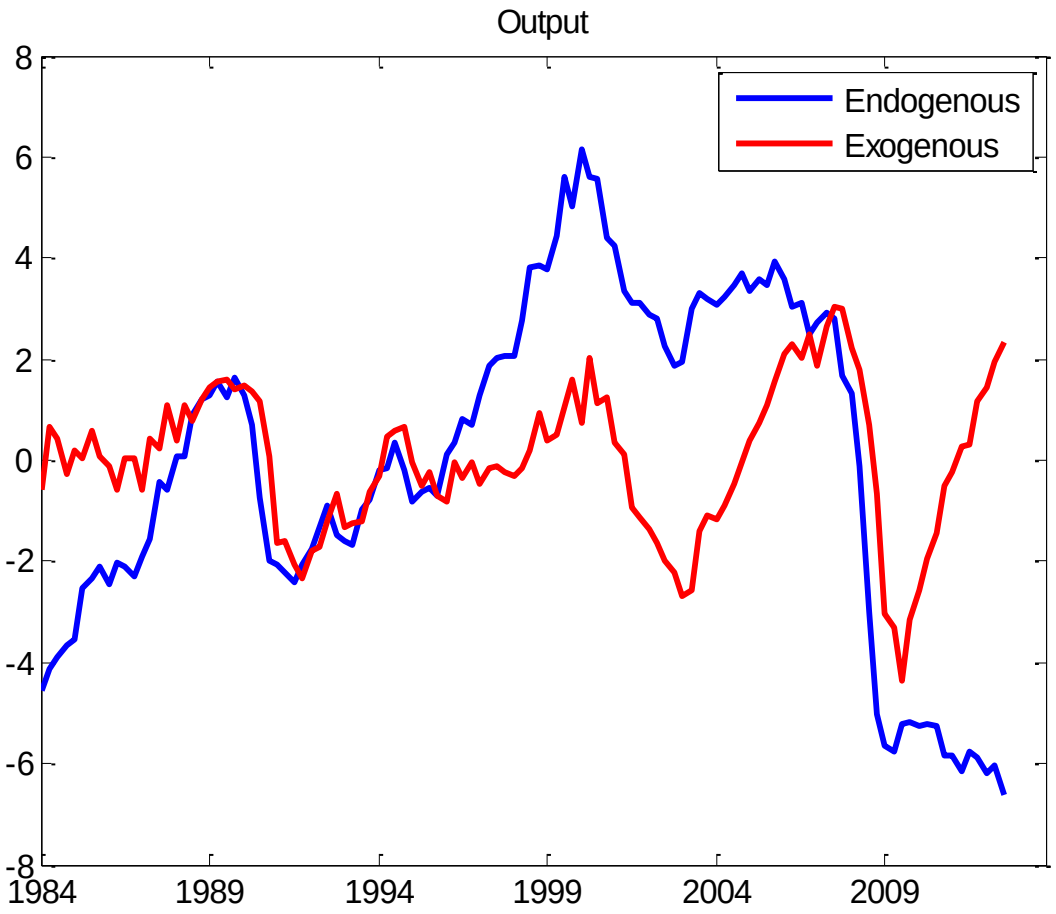
Impact of a credit shock on GDP



How much does this matter?

- Simulate the effect of the shocks that have hit the US economy with and without the mechanisms
- How would the economy have responded if technology was not adjusted by companies over the business cycle…

What if…


Output
Endogenous
Exogenous
8
6
4
2
0
-2
-4
-6
-8
1984
1989
1994
1999
2004
2009

Is this a US only phenomenon?

- Slowdown in technology upgrading by firms contributed significantly to the persistence of the great recession
- Similar to what happened during the “Lost decade” in Japan
- Shocks to developed economies are also propagated through exported technologies to their developing trade partners

INNOVATION POLICY

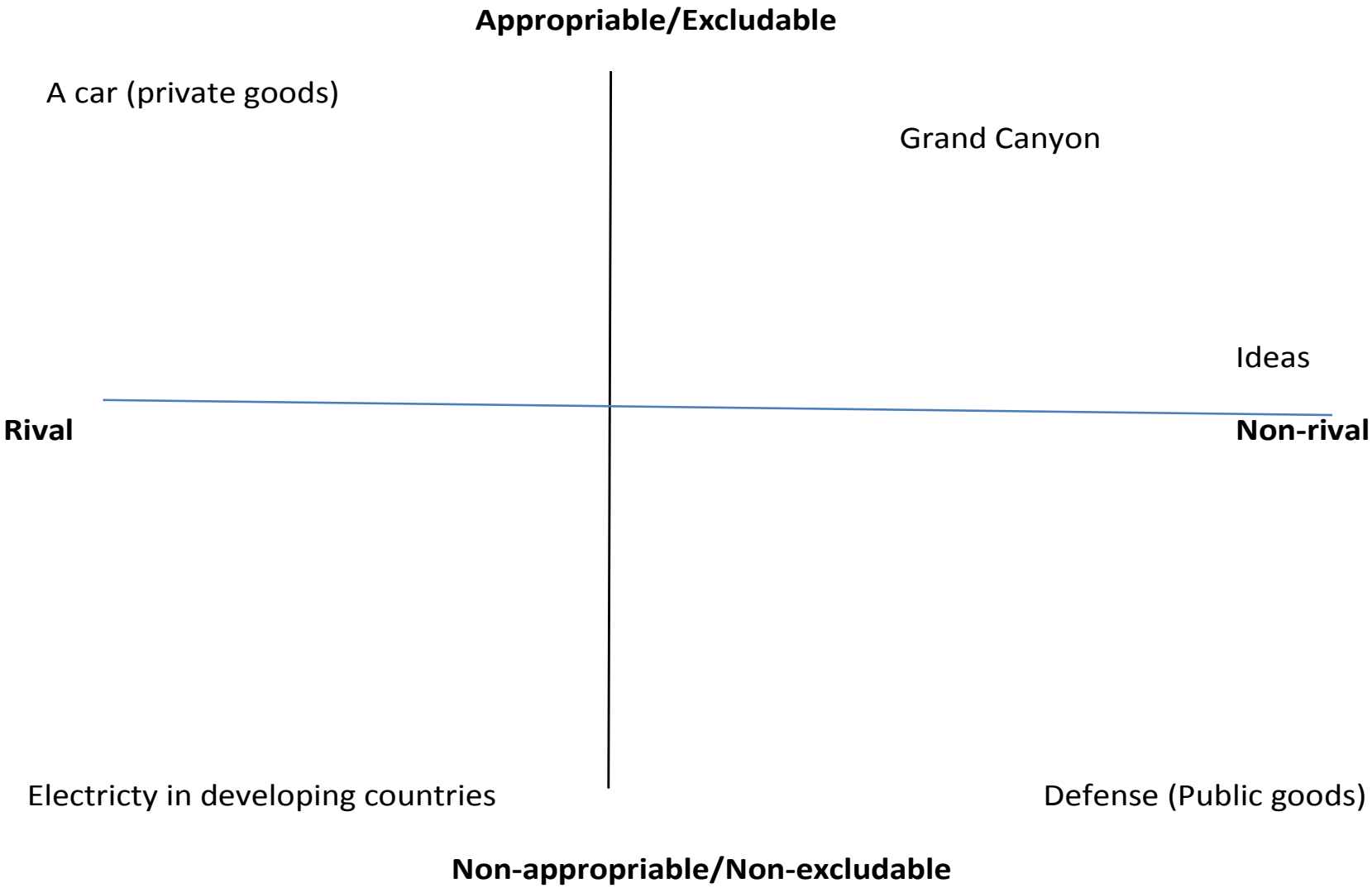
What role should the government play?

- Do governments need to foster innovation?
- How can government foster innovation?
- Is it efficient that most companies innovate?
- Should the government innovate?

The nature of innovation

- Goods and services can be classified according to the degree of
  - Rivalry
  - Appropriability
- Rivalry: my use excludes the others
- Appropriability: It is possible to exclude the others
- Note rivalry a physical property while appropriability is a legal property.

The nature of innovation

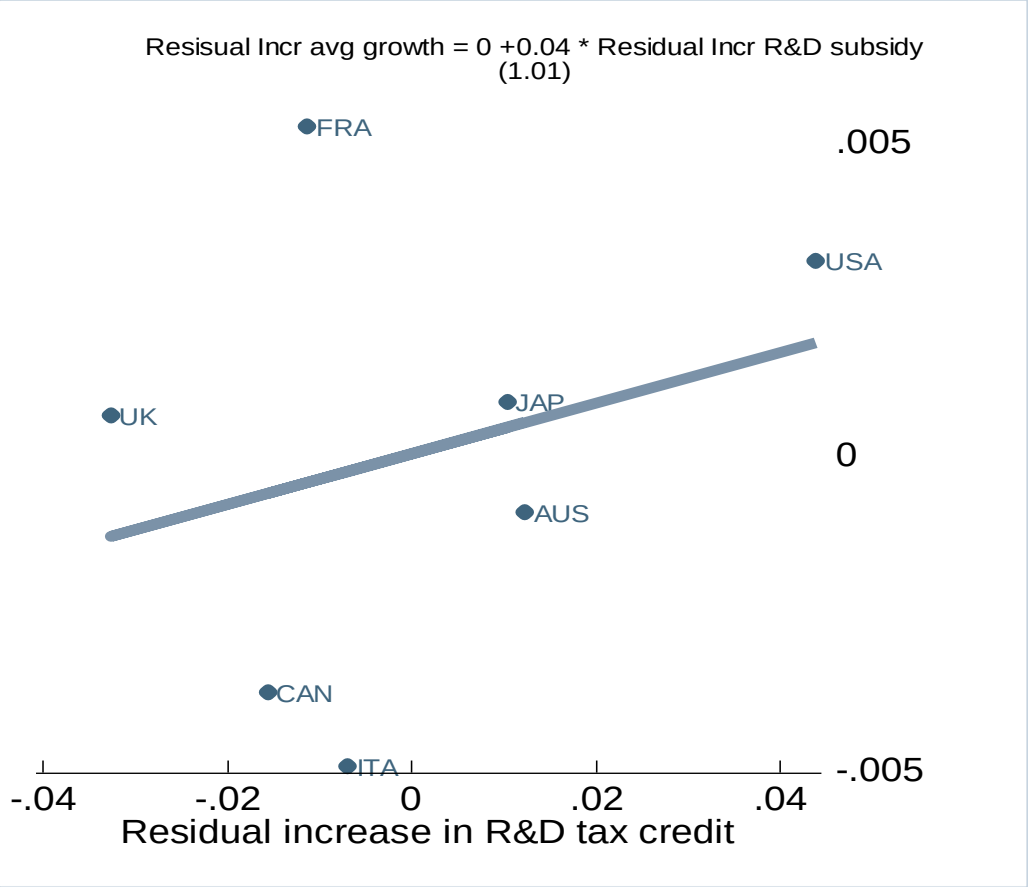


Why is the nature of innovation relevant?

- Role of patents and IPR
  - If no patents then ideas are not appropriable and innovators get no return for their investment.
  - Hence they have no incentive to engage in innovation
- Because innovators do not appropriate all benefits to society from their innovations they tend to underinvest in R&D
- As a result, there tends to be too little innovation in society.
- R&D subsidies may induce companies to invest in R&D

Subsidies and productivity

- However, we have little empirical evidence that subsidies enhances R&D and productivity



Innovation policy

- These frictions suggest that the government should subsidize/tax R&D to encourage/discourage it
- Is there room for government involvement in direct performance of R&D activities?

Fostering innovation

- Is the problem of innovation just the cost?
- Can all companies conduct innovation?
- What if they do not find in the market the solution to their technological problems?
- Do then multiple companies need to come out with similar innovations? Isn't that inneficient?
- What happens with the knowledge an innovator creates that does not fall within its area of expertise?
- Do we lose it just as we lose energy that is not stored?

New innovation policy

- The answer to all these questions is related to the management of technological knowledge

- These questions also point to justifications for public institutions to be involved in the direct development of innovation

The organization of innovation

- Suppose that we create the following organization:
  - Public research organization (public funds, with public objectives vs. profit maximization)
  - Leverages on the knowledge in science and engineering departments of universities
  - Conducts applied research about technologies that could be brought to the market in 2-5 years
  - Uses the knowledge it embodies to develop projects for companies (for a fee) and that allows them to access the technology frontier

The organization of innovation

- This organization exists (in Germany): Fraunhofer
- Great things about Fraunhofer
  - Great at innovating: 500 patents per year
  - Even better at helping companies: 8000 companies/year
  - Covers all areas of science: great to develop projects/innovations that are multi-disciplinary
  - 35% of revenues from private companies

Can the private sector create a Fraunhofer?

- No
- Private companies do not internalize the social value of innovation
- As a result they underinvest in assimilating the knowledge they create
- Furthermore, companies are too narrow to absorb the knowledge that falls in other areas
- Focused on knowledge that can lead to generic products (vs. knowledge that is more central to learning)
- (tend to pass on riskier projects)

Would Malaysia benefit from a Fraunhofer?

- Yes
- Innovations in Palm Oil have shown the importance of joining efforts to develop innovations that are jointly beneficial
- Tradition of manufacturing
- Most companies do not have the knowledge to innovate
- Their technological problems are often too specific to find solutions in the market
- Fraunhofer brings knowledge from universities to firms