

Technological Leadership and Innovation Policy in the World Economy

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Motivation

- Innovations and technological progress are engines of US economic growth and economic leadership in the world.
- However, concerns are rising that the US is losing its leading position through foreign competition.
- Politicians and policy-makers seek for ways to support both public and private R&D.
- Do R&D policies really work? Do they increase US' competitiveness?

Motivating Questions

- Q What are the dynamics of international technology competition?
- Q What are the trade-offs and welfare effects of R&D policies?
 - q How do R&D policies affect a country's competitiveness?
- Q What are the gains/losses from openness? Should a country simply close its borders instead of subsidizing R&D?

To Answer These Questions...

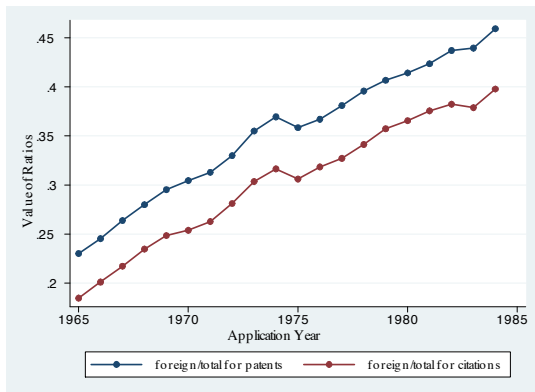
- Need for quantitative analysis with a structural model to understand counterfactuals.
- We analyse an episode of the US economy with aggressive R&D policy changes (80s).

EMPIRICAL FACTS

Fact I: Catching-up until mid-80s

Total Patents (US versus CA + ES + FR + GR + IT + JP + UK)

Figure: Ratio of patents registered in the US: foreign/ total, 1965-1985

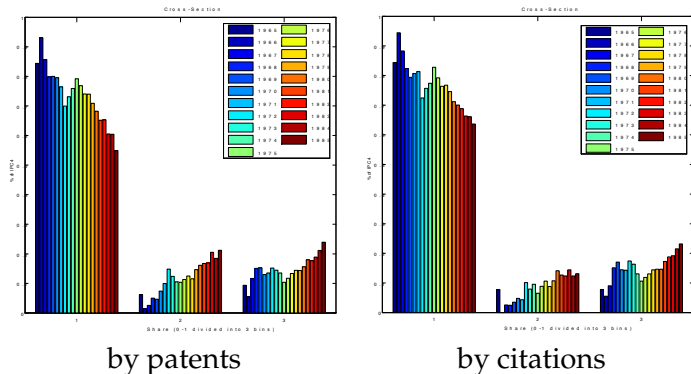


US losing its leading position.

Fact I: Catching-up until mid-80s

Patent by Sectors

Figure: Proportion of sectors led by the US, 1965-1985



... which results in a declining trend in the share of sectors where US dominates.

R&D Policy



R&D Policy



R&D Investment



R&D Policy



R&D Investment



Innovation/Patenting



R&D Policy



R&D Investment



Innovation/Patenting



Import/Export

Fact II: R&D Tax Credit Policy in the US

At the **federal** level:

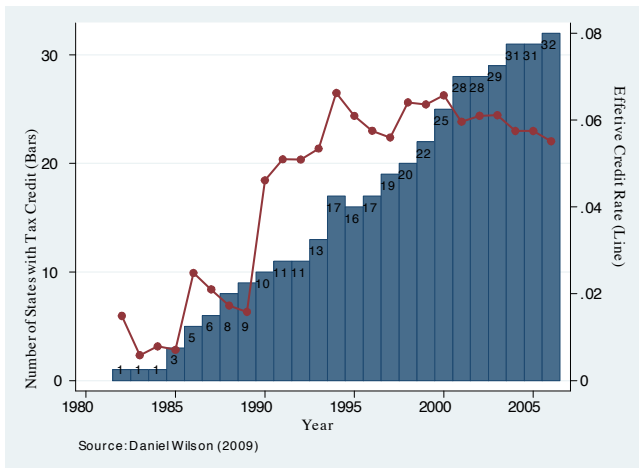
- 1 The Economic Recovery Tax Act of 1981, 1981-85
- 2 The Tax Reform Act of 1986, 1986-88

At the **state** level:

- Started with Minnesota in 1982.

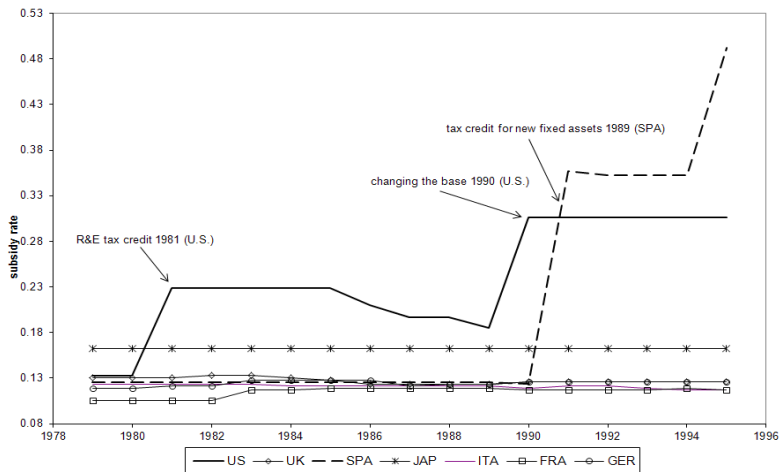
Fact II: State Level Credits in the US

Figure: State level evolution of R&D tax credits



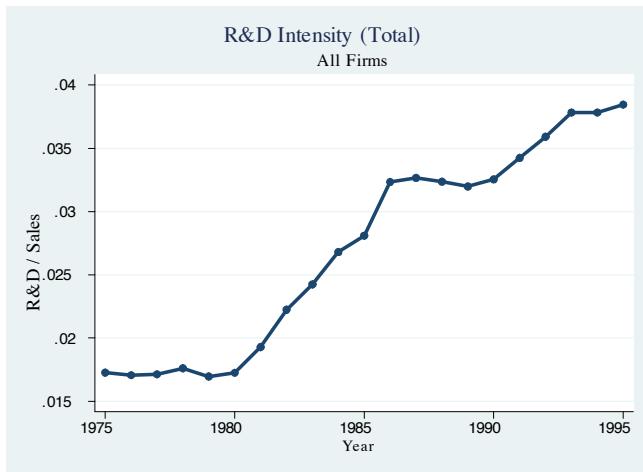
Fact II: Federal-level tax credit in the US

Figure. R&D Tax Credit: Cross-Country Comparison



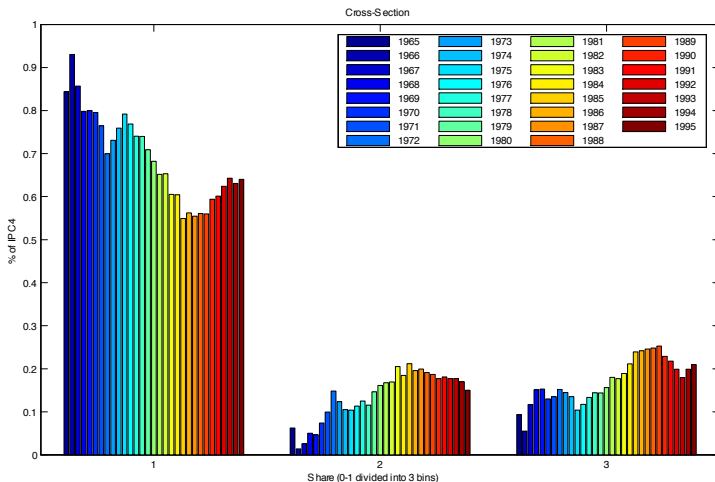
Fact III: R&D Investment

Figure: Total R&D to Sales Ratio (Compustat Firms), 1965-95



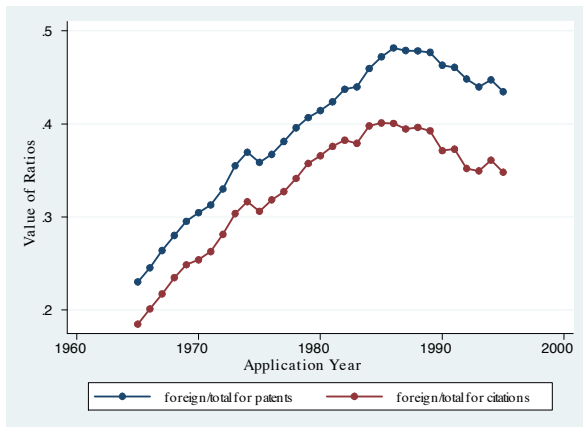
Fact IV: Reversal of Convergence Process

Figure: Proportion of sectors with the US leadership



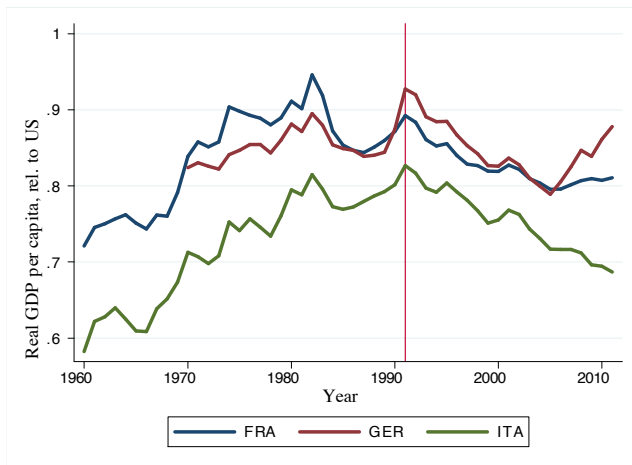
Fact IV: Reversal of Convergence Process

Figure: Ratio of patents and associated citations registered in the US by foreigners over the total, 1965-1995



Fact V: GDP Patterns

Figure: Real GDP per capita - relative to the US, 1960-2010



Cross Sectional Relationship

- Exploit state-level variation in R&D policies across states.

Time Series vs Cross Sectional Relationship

Effect of R&D Tax Credits on Innovative Activity

Dep. Var.:	$\ln(R\&D_t)$	$\ln(Patents_t)$
	(1)	(2)
$\ln(State\ credit_t)$	3.153 (10.92)***	2.948 (10.93)***
Year Dummy	Yes	Yes
Firm Dummy	Yes	Yes

$$\ln Y_{jst} = const. + \ln Y_{jst-1} + \ln SC_{st} + \psi_j + \psi_t + u_t$$

MODEL

Modeling Cross-Country Technological Convergence

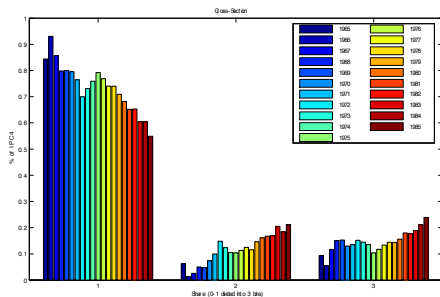
- Endogenous growth model with **Step-by-Step innovation** (Aghion, Harris, Howit and Vickers, 2001) fully **General Equilibrium** (Acemoglu and Akcigit, 2011)
- New features:
 - 1) **Two countries**, $c \in \{A, B\}$, Free Trade and **Costly Trade** scenarios
 - 2) **Transitional dynamics** \rightarrow Technology-driven cross-country convergence process
 - 3) Role of **R&D Tax Credit** in shaping convergence process
 - 4) **Quantitative analysis** \rightarrow tie model to data \rightarrow counterfactual (evaluating Stage-Dependent R&D taxation)

Model in a nutshell

- Two countries, same technology and preferences
- **Final good** → produced with Intermediate Goods (traded) and Labor
- Continuum of **intermediate goods**: in each sector 2 firms (one domestic one foreign) compete for global leadership
- **Innovation**: each firms invest resources to improve quality and get global leadership
- Innovation random → **distribution of leadership** → cross-country income distribution
- **International knowledge spillovers** → leadership (and income) convergence

Quantitative Analysis

Moments



Moment	Target	Estimate
GDP. Growth US	2.16%	2.14%
GDP. Growth Foreign	2.35%	2.24%
R&D Intensity US	1.86%	2.08%
R&D Intensity Foreign	2.07%	2.11%

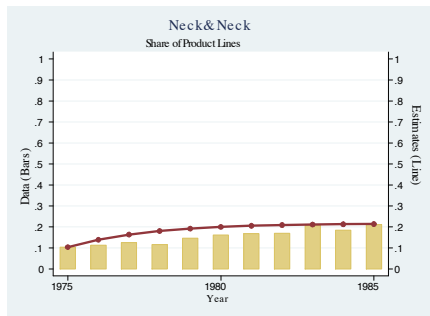
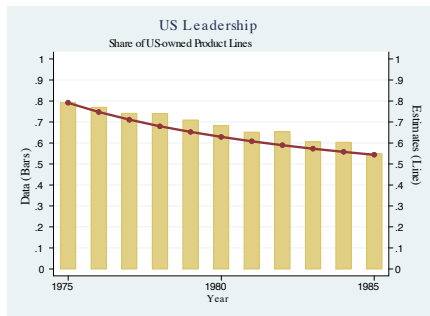
Parameters

Table: Parameter Values

Internally Calibrated				Externally Calibrated	
α_A	57.68	β	0.973	r	2.25%
α_B	108.07	η	$1.785 \cdot 10^3$	τ_{75}^A	17.6%
γ_A	1.954	κ	$1.174 \cdot 10^3$	τ_{75}^B	14.0%
γ_B	2.281	\bar{q}_{1A}	$7 \cdot 10^{-4}$		
λ	1.148	\bar{q}_{-1A}	0.053		

Evolution of Sector Shares

Figure: Calibration Results, Shares of US-owned and Neck&Neck Product Lines



The model is able to capture the adverse pattern of leadership for the US firms, as well as the change in neck&neck sectors, in the relevant time range 1975-85.

Validation Tests

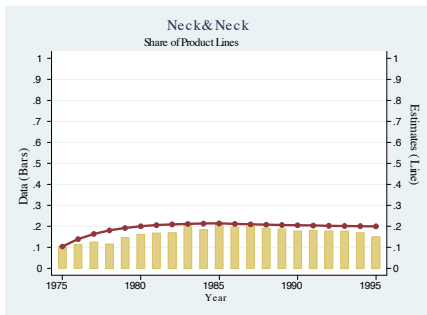
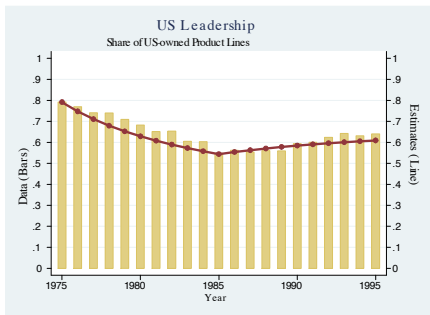
Validation Test I: Leadership Response to Policy

- Replicate the policy change in the data:

$$\tau_{75-85}^A \quad 17.6\% \quad \rightarrow \quad \tau_{86-95}^A \quad 26.3\%$$

$$\tau_{75-85}^B \quad 14.0\% \quad \rightarrow \quad \tau_{86-95}^B \quad 14.7\%$$

Validation Test I: Leadership Response to Policy



Validation Test II: Elasticity of R&D wrt Subsidy

- R&D Elasticity

$$\frac{d \log (\text{R\&D})}{d \log (\text{Subsidy})} \approx 2.88$$

- Compare it to the regression estimate with state credit. 3.15.

Validation Test III: Trade Patterns

- Average Growth Rate of $\left(\frac{\text{Intermediate Goods Import}}{\text{GDP}}\right)$ in the US:

Validation Test III: Trade Patterns

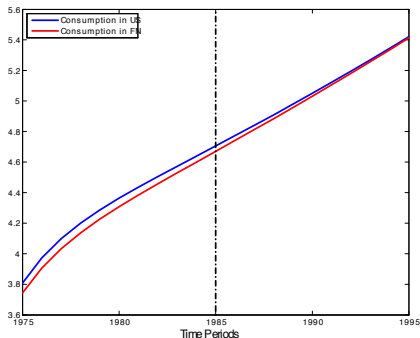
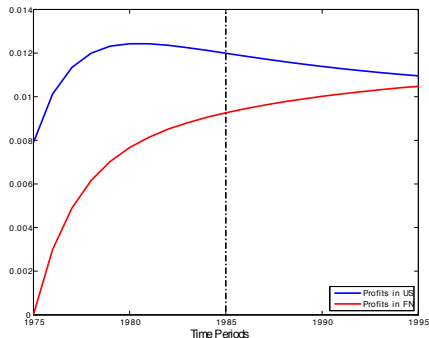
- Average Growth Rate of $\left(\frac{\text{Intermediate Goods Import}}{\text{GDP}}\right)$ in the US:



	Data	Model
1975-1985	8.1%	8.4%
1986-1995	-4.5%	-4.4%

Counterfactuals

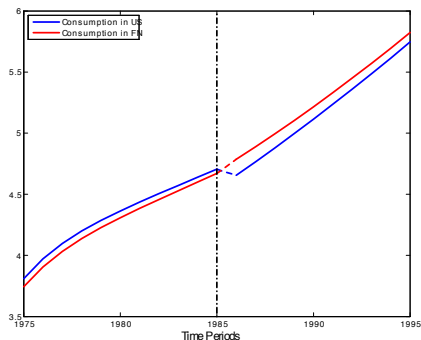
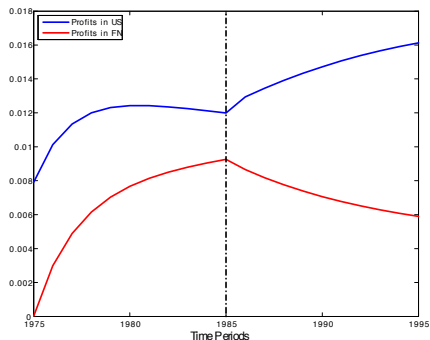
Evolution of the Economies



- The second decade reflects the hypothetical case of no policy change in 1985.

Analysis 1: R&D Tax Credit Policy

Figure: Profits and Consumption with Policy Change in 1985, 1975-95

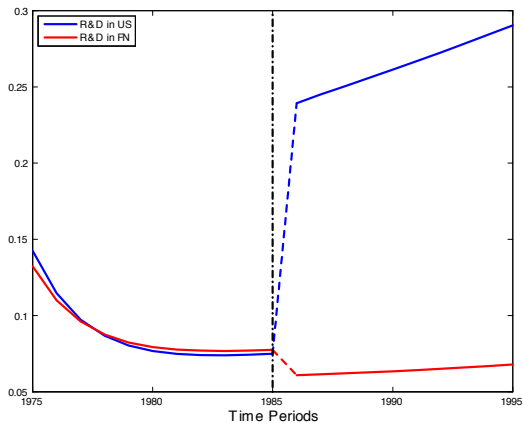


- Reversal of convergence
- Initial drop in consumption due to the jump in R&D expenditure.

Analysis 1: R&D Tax Credit Policy

R&D Expenditures

Figure: R&D Expenditure with Policy Change in 1985, 1975-95



Analysis 1: R&D Tax Credit Policy

Welfare Comparisons

- What is the welfare impact of the policy change in consumption equivalent terms?

Gain 1985-2010
8.49%

Income Growth Decomposition

- **Quality Improvement:** Changes in average quality due to higher innovation intensity, abstracting from ownership changes.
- **Business Stealing:** Changes in the rate of seizing product line leadership, and thus collecting more profits in total, due to increasing innovation intensity.

Table: Income Growth Decomposition, 1985-1995

	w/o Policy	only Quality	w/ Policy	Business	Quality
g_A	1.17%	1.22%	1.43%	81%	19%
g_B	1.31%	2.00%	1.76%	-53%	153%

Analysis 2: Openness to International Markets

OPEN ECONOMY VALUE FUNCTIONS:

$$rV_{1A}(q) = \max_{x_{1A}} \left\{ \begin{array}{l} 2\pi q - q\alpha_A x_{1A}^{\gamma_A} + x_{1A} [V_{1A}(\lambda q) - V_{1A}(q)] \\ + x_{-1B} [V_{0A}(q) - V_{1A}(q)] \end{array} \right\}$$

$$rV_{0A}(q) = \max_{x_{0A}} \left\{ \begin{array}{l} -q\alpha_A x_{0A}^{\gamma_A} + x_{0A} [V_{1A}(\lambda q) - V_{0A}(q)] \\ + x_{0B} [V_{-1A}(q) - V_{0A}(q)] \end{array} \right\}$$

CLOSED ECONOMY VALUE FUNCTION:

$$rV_A(q) = \max_{x_A} \left\{ \pi q - q\alpha_A x_A^{\gamma_A} + x_A [V_A(\lambda q) - V_A(q)] \right\}$$

- (i) Market size (ii) Business stealing (iii) Spillovers (iv) Escape competition

Analysis 2: Openness to International Markets

- What is the welfare impact of openness in consumption equivalent terms?

$$\frac{\text{Gain 1985-2010}}{11.32\%}$$

- 60% of this gain is coming from market size effect.

What we are adding now...

- Free-entry
- Concave utility
- Exploit state level variation in technology catch-up

Conclusion

- Convergence in innovative activity: Sectors with leadership from 79% in 1975 to 55% in 1985
- Effect of R&D subsidies: back to 71% in 10 years (45% otherwise)
- Income growth mainly by business stealing: 81% of income growth increase.
- Welfare gain from policy response: 8.5% in from 1985 to 2010
- Welfare gain from openness: 11.3% in from 1985 to 2010