Taxation and Innovation

Stefanie Stantcheva

(Harvard University)
Innovation is One of Main Drivers of Long-Run Growth

Fact 7: More inventive states and sectors grew faster on average.

Figure 17 shows the basic correlation between patents and economic growth is strongly positive. To account for the initial heterogeneity in income levels, we plot variables residualized against 1900 log GDP per capita.

**Figure 17: Innovation and Long-Run Growth: U.S. States between 1900-2000**

- Residualized Annual GPC Growth Rate 1900−2000
- Residualized Log Patents (1900−2000)

\[
\text{Growth} = 0.000 + 0.066 \times \text{Patents}
\]

Slope coefficient statistically significant at 1% level

Notes:
- Figure plots the total number of patents granted to inventors in each state between 1900 and 2000 on the horizontal axis, and the annualized growth rate in state GDP per capita between 1900 and 2000 on the vertical axis.
- Both horizontal and vertical axes plot the variables of interest residualized against 1900 log GDP per capita, to control for conditional convergence.

Table 6 reports coefficients from growth regressions controlling for the long-run effects of initial conditions and population density. The dependent variable in these regressions is the annualized growth rate in state-level GDP per capita between 1900 and 2000.

**Table 6: Innovation and Long-Run Growth: U.S. States between 1900-2000**

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<tr>
<td>Log Patents</td>
<td>0.066</td>
<td>0.054</td>
<td>0.031</td>
<td>0.026</td>
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<tr>
<td>Initial GDP per Capita</td>
<td>-0.877</td>
<td>-0.891</td>
<td>-0.324</td>
<td>-0.330</td>
</tr>
<tr>
<td>Population Density</td>
<td>1.145</td>
<td>0.517</td>
<td>0.588</td>
<td>0.304</td>
</tr>
</tbody>
</table>

Observations 48 48 48 48
Mean Growth 2.154 2.154 1.552 1.552
Std. Dev. of Growth 0.417 0.417 0.159 0.159

Notes:
- Table reports estimated coefficients from a regression in which the dependent variable is the state-level annualized growth rate in real GDP per capita from 1900-2000.
- White heteroskedasticity robust standard errors reported in parentheses.
- DHS growth rate refers to the growth rate measure as proposed by Davis, Haltiwanger, and Schuh.
- Output data provided by Klein (2013) and the Bureau of Economic Analysis.
- *, **, *** represent that coefficients statistically differ from 0 at the 10%, 5%, and 1% level.

We find that the log of patents granted between 1900 and 2000 had a consistently positive correlation with long-run growth.
In This Talk:

Two ways to study interplay between taxation and innovation:

1. Effects of general taxes on innovation are unwelcome byproduct that we need to consider and quantify.

2. Tax policy could be designed intentionally so as not to hurt, or even to stimulate, innovation.

1. Taxation and Innovation in the U.S. over the 20th Century.

2. International effects of top-income taxation since 1975 on innovation.

3. Designing corporate tax and R&D policies to foster innovation.

Show results, but also research methods and data.
1. Taxation and Innovation in the U.S. over the 20th Century
Taxation and Innovation

Thomas A. Edison
Light bulb.
Holds 1093 patents.

Melvin De Groote
Chocolate ice cream.
Holds 925 Patents.

Nikola Tesla
Alternating Current.
Holds 278 Patents.
Taxation and Innovation

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Mad geniuses? Scientific pioneers not considering net returns?
Taxation and Innovation

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Or were these inventors affected by taxes?
Taxation and Innovation

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Personal taxes? Corporate taxes?
Taxation and Innovation

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A Large-Scale Historical Project

- How do taxes affect innovation?
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- Challenging question, to a large extent unanswered.
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- We leverage three newly constructed datasets for the U.S.:
  i) Panel of the universe of U.S. inventors since 1920 and their patents.
  ii) Panel of all R&D labs (employment, location, patents) since 1921.
  iii) Historical state-level corporate tax database.
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  3. Historical state-level corporate tax database.
- Study systematically the effects of **personal and corporate income taxes** since 1920 on:
  1. Individual inventors (micro level).
  2. Firms that do R&D (micro level).
  3. Innovation in states (macro level).
A Large-Scale Historical Project

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  3. Innovation in states (macro level).

- Sheds light on taxation more generally (entrepreneurship, mobility, labor supply..)
To the Honorable Commissioner of Patents:
Your Petitioner THOMAS A. EDISON
of Menlo Park in the State of New Jersey
prays that LETTERS PATENT may be granted to him
for the invention of an Improvement in Electric Lamps
and in the method of manufacturing the same
(Record 1880)

And further prays that you will empower LEWEL W. SIRRELL, of
the City of New York, N.Y., as his Attorney, with full power
of substitution and execution, to prosecute this application, to make additions and amendments therein, to secure the Patent, and to transact all business of the Patent Office connected therewith.

<table>
<thead>
<tr>
<th>fname</th>
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Your Petitioner, THOMAS A. EDISON
of Menlo Park, in the State of New Jersey,
prays that LETTERS PATENT may be granted to him,
for the invention of an improvement in Electric Lamps
and in the method of manufacturing the same,
set forth in the annexed specification.

And further prays that you will empower
LEMMUEL W. SERRILL, of
the City of New York, N.Y., as his Attorney, with full power
of substitution and execution, to prosecute this application, to make alterations and amendments therein, to secure the Patent, and to transact all business of the Patent Office connected therewith.

THOMAS EDISON

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And further reports that you will empower Lemuel W. Terrell, of the City of New York, N.Y., as your Attorney, with full power of substitution and execution, to prosecute this application, to make alterations and amendments therein, to secure the Patent, and to transact all business in the Patent Office connected therewith.

THOMAS  EDISON  1880  32  Married  OHIO  MENLO PARK
THOMAS  EDISON  1900  52  Married  OHIO  MENLO PARK
WILLIAM  WINE  1920  38  Married  VIRGINIA  TOLEDO WARD 4
ADIEL  DODGE  1940  48  Married  MISSOURI  ROCKFORD
R&D Labs Data

Compiled from National Research Council (NRC) Surveys of *Industrial Research Laboratories of the United States (IRLUS)*

The NRC sent firms questionnaires – the IRLUS volumes contain the firm-level summary data responses.

- Data were hand entered from the 1921, 1927, 1931, 1933, 1938, 1940, 1946, 1950, 1956, 1960, 1965 and 1970 editions of IRLUS
3004. Polaroid Corp., 730 Main St., Cambridge 39, Mass. (Cp)

Research staff: Edwin H. Land, President and Director of Research; Robert M. Palmer, Manager, College Personnel Relations; 50 chemists, 5 engineers, 1 mathematician, 9 physicists, 90 technicians, 18 auxiliaries.

Research on: One-step, three-dimensional, and color photography; color vision; chemistry of photographic processes; polarized light; polymers; absorption of light; organic chemistry; physics and crystallography, especially as related to phenomena involving radiation; spectroscopy; electronics.
How can we measure innovation?

At the macro state-level:

   Number of inventors

   Number of patents

   Number of citations

   Share of corporate patents.

At the individual inventor and firm level:

   Do you patent at all? How many patents over the next years?

   How many citations? Home-run patent?

   Where do you locate?

   How many researchers do you hire (firms)?

   Do you work in corporate sector (inventors)?
Why should we worry about both personal and corporate taxes?
Geography of innovation. Inventors per 10,000: 1920
Geography of innovation. Inventors per 10,000: 1920-1930

0 - .5 (1)
.5 - 1 (7)
1 - 1.5 (4)
1.5 - 2 (6)
2 - 3 (9)
3 - 5 (16)
5 - 10 (4)
10 - 20 (1)
Geography of innovation. Inventors per 10,000: 1930-1940
Geography of innovation. Inventors per 10,000: 1940-1950
Geography of innovation: Inventors per 10,000: 1980-1990

The map shows the distribution of inventors per 10,000 population across the United States from 1980 to 1990. The states are color-coded to indicate different ranges of inventors per 10,000 population.

- 0 - .5 (2) states
- .5 - 1 (11) states
- 1 - 1.5 (13) states
- 1.5 - 2 (4) states
- 2 - 3 (14) states
- 3 - 5 (3) states
- 5 - 10 (1) state
- 10 - 20 (0) state
Geography of innovation. Inventors per 10,000: 1990-2000
Location of R&D Labs - 1933
Location of R&D Labs - 1950

Number of R&D Labs
- 0 to 2
- 2 to 6
- 6 to 10
- 10 to 20
- 20 to 100
- 100 to 350
- 350 to 760
How can we study the effects of taxes on innovation?

Innovation Outcome = $\beta_1 \times \text{Income tax} + \beta_2 \times \text{Corporate tax} + \text{Controls}$.

Macro level (state) and micro level (individual inventor and firm).

Many confounding factors: Taxes changed jointly with other policies or in response to local econ conditions!

Need a proper empirical strategy.

“Fixed effects:” filter out characteristics constant within year & states.

“Instrumental variables:” use only changes in total tax burdens driven by federal-level changes.

Compare border counties in neighboring states.

Event studies: look before and after sharp tax changes.
States Have Changed their Tax Rates a Lot over Time

1940

[Graph showing state tax rates over time with different symbols representing median and 90th percentile of MTR and ATR.]
States Have Changed their Tax Rates a Lot over Time

1940

- MTR (Median)
- MTR (90th)
- ATR (Median)
- ATR (90th)
Main Results

Personal income and corporate income taxes—negatively influence:

1. Quantity of innovation,
2. Quality of innovation,
3. Location of innovation.

At the macro level, cross-state spillovers and business-stealing are important, but not the full story.

Corporate inventors more reactive to personal, but especially to corporate taxes (to net returns in general?).

Could be differential exposure or different motives.

Agglomeration appears to matter: inventors are less sensitive to taxation where there is already more innovation in their own field.
Taxes and International Migration: Anecdotes but Little Evidence

- Is the “brain drain” in response to taxes real? Lots of anecdotes:
  - Famous people migrating for tax reasons? Rolling Stones to France (!), David Bowie to Switzerland, Rod Stewart to California, Sting to Ireland, Gerard Depardieu’s Russian citizenship, Edoardo Saverin (facebook co-founder) to Singapore, ...

- Scarcity of rigorous evidence due to a lack of international panel data.
  - Exceptions: Kleven, Landais and Saez (2013) on football players.

- This paper: study the effect of taxes on the international mobility of inventors.
Study the Effects of Taxes on Migration using Patent Data

- Use a **unique international panel data** to overcome challenges:
  - Track inventors in 8 big patenting countries: CA, CH, DE, FR, IT, JP, UK, US through residential addresses.
- Study effects of **top tax rates** on “superstar” inventors’ locations.
- Patent data gives direct measures of inventor quality.
- Detailed controls for **counterfactual** earnings in each potential location.

**Three levels of analysis:**

1. Macro country-year level migration flows (country-by-year variation).
2. Country case studies (quasi-experimental variation from reforms).
3. Micro inventor level location choice model (differential impact of top MTR within country-year. Inventor quality → ↑ propensity to be treated).
Preview of Findings

- Superstar top 1% inventors’ location choice significantly affected by top tax rates.
- If have worked for multinationals more sensitive to tax differentials.
- If company has localized research activity, less sensitive.
Link between Inventor Quality and Income in IRS data

Source: Bell et al. (2015).
Link between Inventor Quality and Income in IRS data

\[ \text{income} = \text{200,000} + 1,400 \times \text{citations} \]

Source: Bell et al. (2015).
Link between Inventor Quality and Income in IRS data

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![Graph showing the relationship between citations and income for different percentiles of inventors.]

- **Below Top 25%**: 230,774
- **Top 10-25%**: 370,975
- **Top 5-10%**: 549,460
- **Top 1-5%**: 883,970
- **Top 1%**: 2,285,405

**Source:** Bell et al. (2015).
Case Study: U.S. TRA 1986

![Graph showing the relationship between top tax rate differential and foreign top 1% inventors from 1982 to 1992. The graph illustrates a sharp decrease in the top tax rate differential around 1988, indicating a significant change in tax policy.]
Case Study: U.S. TRA 1986

![Graph showing the top tax rate differential and foreign top 1% inventors from 1982 to 1992. The graph highlights a significant decrease in the top tax rate differential in 1988, coinciding with a decrease in foreign top 1% inventors.](image-url)
Case Study: U.S. TRA 1986

The graph shows the trend of Foreign Top 1% Inventors and the Top tax rate differential from 1982 to 1992. The top tax rate differential is depicted by red dots, and the trend is indicated by a red line. The synthetic U.S. data is shown by a black dashed line. The graph highlights a significant decrease in the top tax rate differential in 1988, coinciding with a sharp decline in the number of Foreign Top 1% Inventors.
Case Study: U.S. TRA 1986

The graph shows the trend of Foreign Top 1% Inventors and Top tax rate differential from 1982 to 1992. The Top tax rate differential is indicated by a red line, while the Foreign Top 1% Inventors are represented by a black line. The graph highlights a significant drop in the Top tax rate differential in 1988, which corresponds to a peak in Foreign Top 1% Inventors.
Case Study: U.S. TRA 1986

Elasticity = 3.42 (0.654)

Year | U.S. | Synthetic U.S. | Top tax rate differential |
--- | --- | --- | ---
1982 | 26 | -0.4 | -0.4 |
1984 | 44 | -0.3 | -0.3 |
1986 | - | - | - |
1988 | - | - | - |
1990 | - | - | - |
1992 | - | - | - |

Foreign Top 1% Inventors
Case Study: U.S. TRA 1986

Structural break in growth of foreign top 1% relative to lower quality inventors.

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Case Study: Denmark’s 1992 Preferential Tax Reform

Elasticity = 0.71 (0.242)

Top tax rate differential

Norm. share of foreign inventors

Year

Denmark
Synthetic Denmark
Top tax rate differential
3. Designing Corporate Tax and R&D Policies
Motivation I: Widespread and Diverse R&D Policies

“The need to foster greater innovation and productivity growth is one of the most important economic challenges we face, and tax policy is one of several important levers that policymakers can use”, J. Furman, former chairman of CEA

Businesses spend a lot of resources on R&D... and the government already intervenes heavily.

Large variety of policies target innovation and R&D

- Tax credits, deductions, grants, contracts, direct funding in FFRDCs, Universities, Firms, small business, start-ups...

- Large variety of policies across countries as well.

R&D policies are widespread, not fully understood, & very costly:
  - “Intramural” R&D cost $35 billion (2014).
  - “Extramural” R&D: tax credit $11 bil in 2012, contracting with non FFRDCs 50,6 billion, NSF-NIH $40 billion (econ grant: 0.0025%)
Is the amount spent by government correlated with better productivity?
Motivation II: Private Information is an Important Constraint

- Take young firms at start of their lifecycle. How much of the variation in subsequent innovation quantity & quality can we explain based on observables?
  - Observables: age, assets, past investments, sales, state FE, year FE, sector FE (+ all interactions), and even past innovations:
  - $R^2$ not above 0.3, improves with age (as info revealed).
  - Conditional on these observables, many “outlier” firms.

- Two ways of possibly addressing asymmetric info problem:
  - Direct screening: what the NSF and VCs try to do. Done by the government with public procurement. Hard to do and very costly on a large scale.
  - Indirect screening: Design a menu of options (implemented by taxes and subsidies), let firms self-select! “Easy” to decentralize and scalable.
What are Key Ingredients to consider?

Firms have different productivities that evolve over time, somewhat unpredictably.

Productivity: efficiency of converting R&D inputs into innovation output.

Some inputs are observable (R&D Investments) and can be subsidized; others are unobservable (R&D effort).

Uncertainty about R&D returns at the time investments are made.

Spillovers between firms: one firm’s innovations affect other firms (+ society).

Innovation not appropriable unless IPR.

Firm productivity is private information.

What should the government/regulator do? How can it pick winners and not subsidize losers?
1) “Mechanism design approach:” what is the best we can do under this info constraint?

2) Quantitative Investigation using Patent data + Longitudinal Business Database (LBD) data.
   
   Can see the observable inputs to innovation and outputs (patents & citations).

3) Can now simulate effects of any policies! What simpler policy reforms can help?
Main Findings

Relative to current policies, a lot can be gained by better “targeting” and screening of R&D subsidies/credits to firms.

Key parameters and trade-off: How complementary are the (observable) subsidized R&D investments to firm productivity vs. to the (unobservable) not-subsidized inputs.

If very complementary to firm productivity, very costly to subsidize as good firms extract very high rents (paid for by general tax $!)

Reforms that can save a lot of revenues while still fostering innovation:

Condition corporate tax and R&D subsidies for innovative firms on i) age; ii) size; iii) past performance.
Conclusion: So.. should we slash taxes?

This is just one part of the (literal) equation – namely part of the efficiency cost.

\[ \tau^* = \frac{1 - \bar{g}}{1 - \bar{g} + e} + \frac{\text{Social preferences}}{\text{Externalities}} + \frac{\text{C}}{\text{Efficiency effects}} \]

The desired level of taxes crucially depends on your “social preferences” and wish for redistribution.

This is not something the data can tell us..