# How Do Patent Laws Influence Innovation? Evidence From Nineteenth-century World Fairs

Petra Moser (American Economic Review, 2005)

# How do Patent Laws Influence Innovation?

- Patents are designed to influence innovation, but we do not know exactly how this works
- International policies introduce and strengthen patent laws (TRIPS)
- Previous studies focused almost exclusively on levels of innovations
- But direction of innovative activity matters
- Data problems with existing sources

# New Data on Innovation: Records of 19th Century World Fairs

- Catalogues of world fairs of 1851 and 1876
  - Economically useful innovation
  - Economy-wide
  - Comparable across countries
  - Awards as a measure of quality
- Patent laws do not appear to raise levels of innovative activity
- Concentrate innovative activity on a small set of industries
- Secrecy is effective relative to patents

# Potential Sources of Bias

- Heavy, large, and fragile exhibits
  - Space restrictions were flexible
  - Models and blueprints
  - Few showy exhibits
- Fear of copying
  - Exhibit output rather than machinery
  - System of registration

# Simple Theoretical Framework

Suppose

- Inventors can decide between industries
- Industries differ in effectiveness of patents
  - Easy to reverse-engineer: Manufacturing and agricultural machinery
  - Easy to keep secret: Food, dyestuffs, scientific instruments

Then, as patent length decreases, industries with secrecy become more attractive

# The Exhibition Data

- Exhibits listed in catalogues for 19th-century fairs of technology
  - 32 Bendall, J., Woodbridge, Manu. - A universal self-adjusting cultivator, for skimming, cleaning, pulverizing, or subsoiling land, pat.
- Crystal Palace Exhibition in London, 1851
- Centennial Exhibition in Philadelphia, 1876
  - Crystal palace class 9 “Agricultural Machinery” and centennial class 670 “Machinery for Tillage”

# Why use Exhibition Data To Study Effects of Patent Laws?

- Independent of changes in patent laws
- Available for all industries
- Comparable across countries
- Innovations rather than inventions
- Control for quality
  - Three types of awards to distinguish novelty and usefulness

# Exhibits are selected for novelty and usefulness

## Crystal Palace Commission

Prince Albert
Sir Robert Peel
Henry Cole

Appoint

Space

## International Juries

½ British
½ visiting countries
academics, businessmen, industry experts

## National Commissions

Appoint

Check selection of local commissions

Appoint

Evaluate all exhibits according to novelty and usefulness

Council Medals 1 percent
Prize Medals 18 percent
Honorable Mentions 12 percent

## Local Commissions

5 local business people
5 academics

Solicit exhibits and select according to novelty and usefulness

# Potential Sources of Bias

- Heavy, large, and fragile exhibits
  - Space restrictions were flexible
  - Models and blueprints
  - Few showy exhibits
- Fear of copying
  - Bias against secrecy inventions
  - Exhibit output rather than machinery
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# Sample Sizes in Studies of Innovation

- Case studies of individual countries
  - Schmookler (1966), Sokoloff (1988), Rosenberg (1972): U.S.
  - Sakakibara and Branstetter (2000): U.S. and Japan
- With exhibition data:
  - 12 countries in 1851, 2 without patent laws
  - 10 countries in 1876, 2 without patent laws

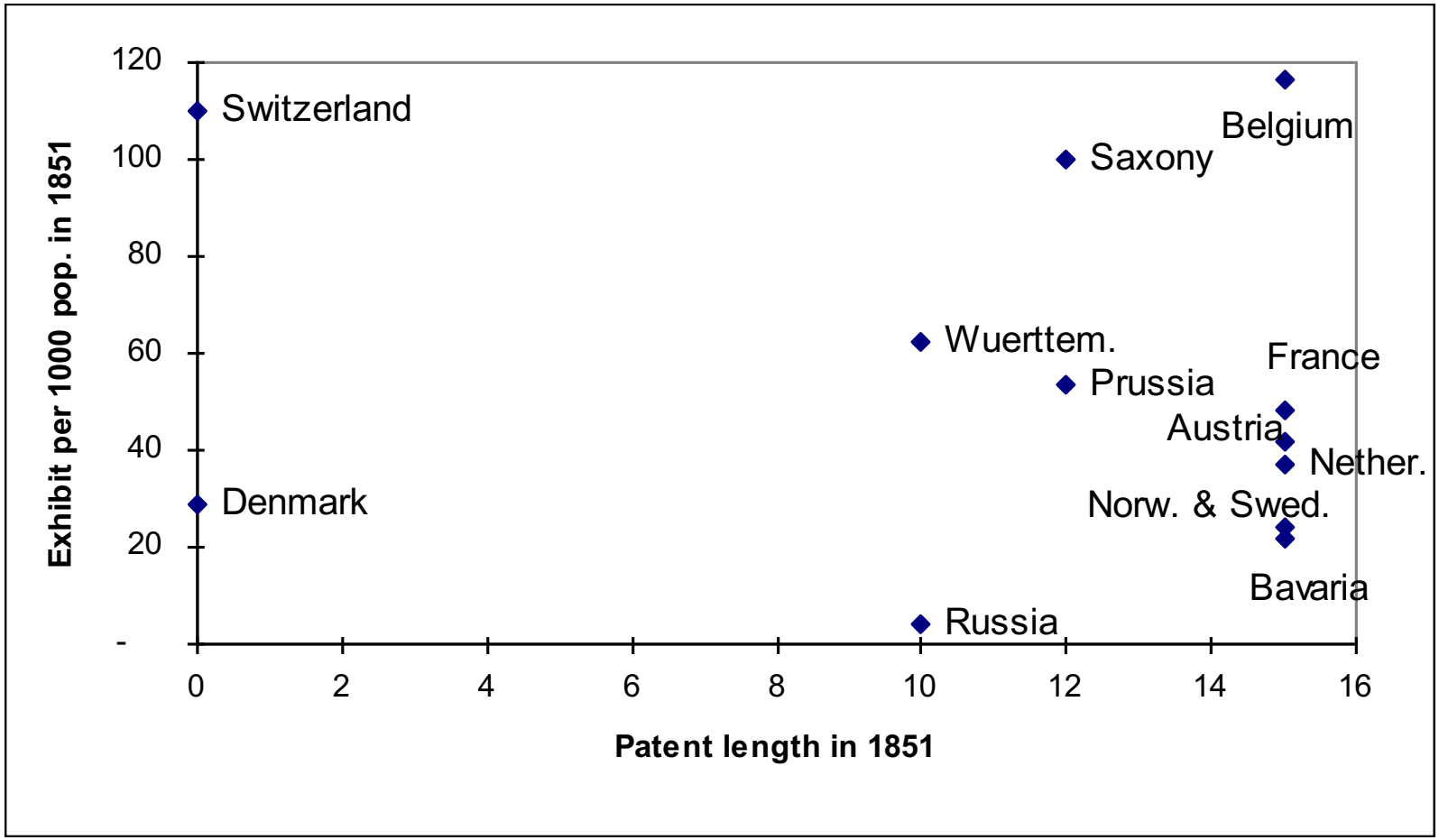
| Exhibition | Year | Location | Countries | | Exhibitors | |
|---|---|---|---|---|---|---|
| | | | Total | N.Europe | Total | N.Europe |
| **Crystal Palace** | 1851 | London | 40 | 12 | 13,876 | 11,610 |
| **Centennial** | 1876 | Philadelphia | 35 | 10 | 30,864 | 6,482 |

# Summary of Empirical Results

Countries without patent laws…

- do not exhibit fewer innovations
- do not exhibit fewer innovation of high quality
- focus innovation on specific industries
  - Scientific instruments, food processing
  - Patenting rates in these industries are low
  - Surveys and narrative evidence show that inventors relied on alternatives to patent grants

# Countries Without Patent Laws Do Not Exhibit Fewer Innovations



# *Ex ante* it's unclear whether patents encourage or discourage innovation

- Patents encourage innovation
  - Strengthen incentives to create patentable domestic inventions

But

- patents are not the only mechanism to encourage innovation
  - Alternative means to protect intellectual property are more effective than patents in most industries (Cohen, Nelson, and Walsh NBER 2000)
  - Most inventions were not patented historically (Moser JLawEcon "Innovation without Patents" 2012, JEP )
- Moreover, patents may *discourage* innovation downstream
  - If they make it harder to adopt (copy/steal) foreign inventions (e.g., Unilever and many other examples of firms growing out of piracy in book project on *Pirates and Patents,* building on Schiff 1971)
  - If they raise reduce expected profits for later generations of inventors ("cumulative innovation" Scotchmer in "Standing on the Shoulders of Giants – Cumulative Research and the Patent Law" JEP 1991)

# Do patent laws influence the direction of innovation?

- Direction vs. levels
  - People usually ask “how much”
  - But ”what” is just as important, e.g., because the direction of innovation determines patterns of comparative advantage

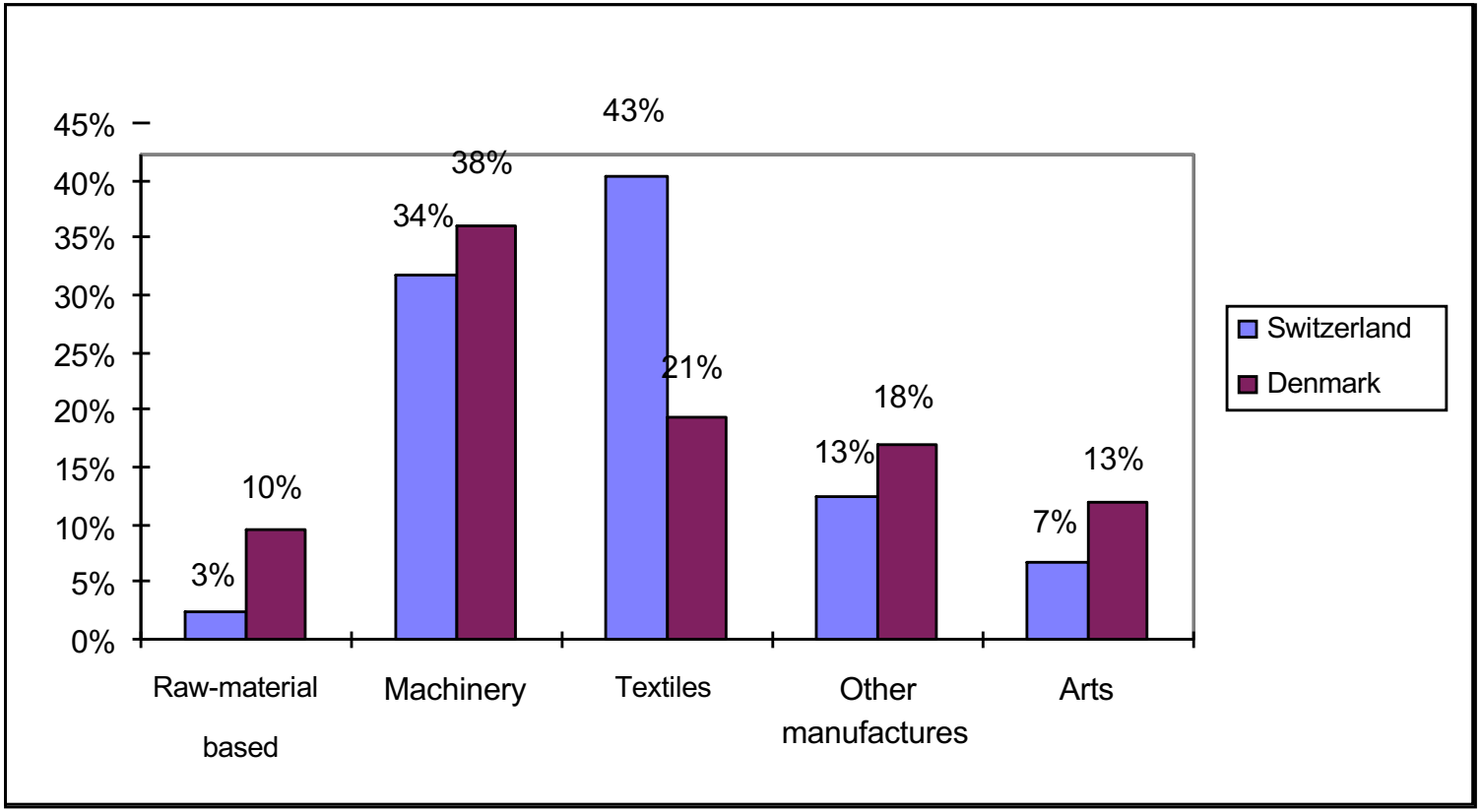
- A simple test: Chi-square tests of homogeneity
  - Ho: distributions of exhibits are identical across countries that share the same patent length
  - $Y_{ij}$ observed counts in industry i and country j
  - $E_{ij} = Y_{i\,j}\, Y_{i\,j} /\ \ Y_{i\,j}$ expected counts
  - Test statistic $Q = [Y_{ij} - E_{ij}]^2 / [E_{ij}]$ approximately chi-square distributed with (I - 1)(J - 1) degrees of freedom

# Countries w/o patent laws (T=0) are much more similar to each other than countries w patents

**Differences in the distribution of exhibits across 5 industry classes in 1851**

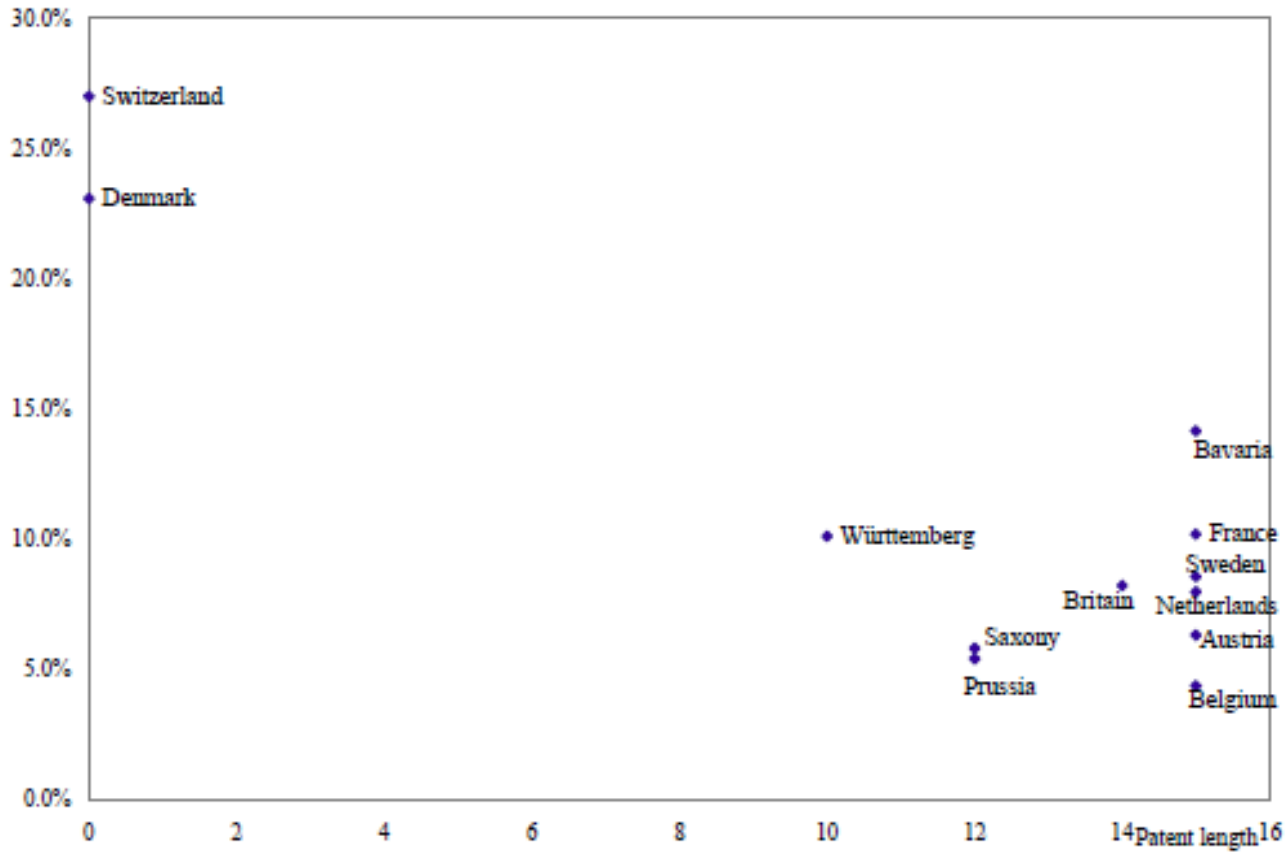
| Patent length | Number of countries | Chi-square statistic | Degrees of freedom |
|---|---|---|---|
| All T | 12 | 475.94 | 44 |
| 0 | 2 | 11.73 | 4 |
| 10 | 2 | 79.49 | 4 |
| 12 | 2 | 76.97 | 4 |
| 15 | 6 | 146.44 | 20 |

# Exhibits of Countries Without Patents Are Distributed Similarly Across Industries



# Countries Without Patent Laws Have Greater Shares of Exhibits in Scientific Instruments

FIGURE 1 – SHARES OF EXHIBITS IN SCIENTIFIC INSTRUMENTS AGAINST PATENT LENGTH IN 1851




*Notes*: "Share of exhibits in scientific instruments" measures the proportion of a country's exhibits that occur in the industry class "scientific instruments." Patent length measures the maximum duration of a patent grant in 1851 as reported in Coryton (1855) and Lerner (2000).

# Why scientific instruments?

- Astronomical clocks, watches, optical lenses, barometers, theodolites,...

- Depend on skill and detailed knowledge of production processes
- Difficult to reverse-engineer
- Suitable for secrecy => less dependent on patenting

Small antique English magnifying glass, ca. 1850, photocredit, 1stDibs.co.uk

# 19th Century Sources Describe Secrecy in Watch-Making

- Thomas Mudge
- Vacheron and Constantin
  - Georges-Auguste Leschot to invent machines to manufacture watch movements
- Geneva's watchmakers
  - Machine tools
- Vallée de Joux 1823-1840
  - Agree not to take apprentices to maintain trade secrecy surrounding sonnerie des minutes


Watchmaking in the Swiss Vallée de Joux, image credit, www.lionel-meylan.ch

# Patenting rates vary across industries

| | British exhibits | |
|---|---|---|
| **Industry** | **Total** | **% Patented** |
| Mining | 418 | 5.0% |
| Chemicals | 136 | 7.4% |
| Food processing | 140 | 8.6% |
| Engines and Carriages | 406 | 32.8% |
| Manufacturing Machinery | 242 | 35.5% |
| Civil Engineering | 203 | 18.7% |
| Military and Naval Engineering | 356 | 13.5% |
| Agricultural Machinery | 261 | 28.4% |
| Scientific Instruments | 581 | 11.4% |
| Manufactures | 1,955 | 13.1% |
| Textiles | 1,679 | 7.6% |
| **All industries** | 6,377 | 13.3% |

# Machinery innovations depend on patenting

- Many examples of failed attempts at secrecy
- Isaac Singer's sewing machine
  - In 1850 11 days to reverse-engineer Lerow & Blodgett
  - Improvements yield first practicable sewing machine
  - Did not manage to break patent of Elias Howe
  - $25 in royalties for every sewing machine sold in the US
- Thomas Hancock's masticator
  - Cylinder studded with sharp teeth
  - Gnaws and macerates rubber into scraps
  - Called the "pickle", oath not to discuss
  - Former worker squeals and competitors rush in
  - Only protection from patents on rainwear and suspenders

# Even quality-adjusted, innovations in machinery are more likely to be patented

Shares of patented innovations, British exhibits in 1851

| | Award-winning British exhibits in 1851 | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | All levels | | Gold | | Silver | | Bronze | |
| **Industry** | **Total** | **% Patented** | **Total** | **% Patented** | **Total** | **% Patented** | **Total** | **% Patented** |
| Mining | 102 | 2.9% | 2 | 50.0% | 53 | 1.9% | 47 | 2.1% |
| Chemicals | 74 | 8.1% | 0 | NA | 42 | 11.9% | 32 | 3.1% |
| Food processing | 63 | 4.8% | 1 | 0.0% | 39 | 7.7% | 23 | 0.0% |
| Engines and Carriages | 12 | 25.0% | 6 | 50.0% | 4 | 0.0% | 2 | 0.0% |
| Manufacturing Machinery | 72 | 47.2% | 14 | 42.9% | 57 | 47.4% | 1 | 100.0% |
| Civil Engineering | 36 | 19.4% | 3 | 0.0% | 25 | 20.0% | 8 | 25.0% |
| Military and Naval Engineering | 65 | 10.8% | 8 | 0.0% | 49 | 14.3% | 8 | 0.0% |
| Agricultural Machinery | 47 | 36.2% | 5 | 40.0% | 37 | 37.8% | 5 | 20.0% |
| Scientific Instruments | 72 | 16.7% | 14 | 21.4% | 43 | 12.5% | 15 | 26.7% |
| Manufactures | 424 | 18.6% | 19 | 10.5% | 294 | 16.9% | 111 | 6.3% |
| Textiles | 482 | 8.9% | 3 | 100.0% | 308 | 8.8% | 171 | 8.8% |
| **All industries** | 1,449 | 14.1% | 75 | 24% | 951 | 16% | 423 | 8% |

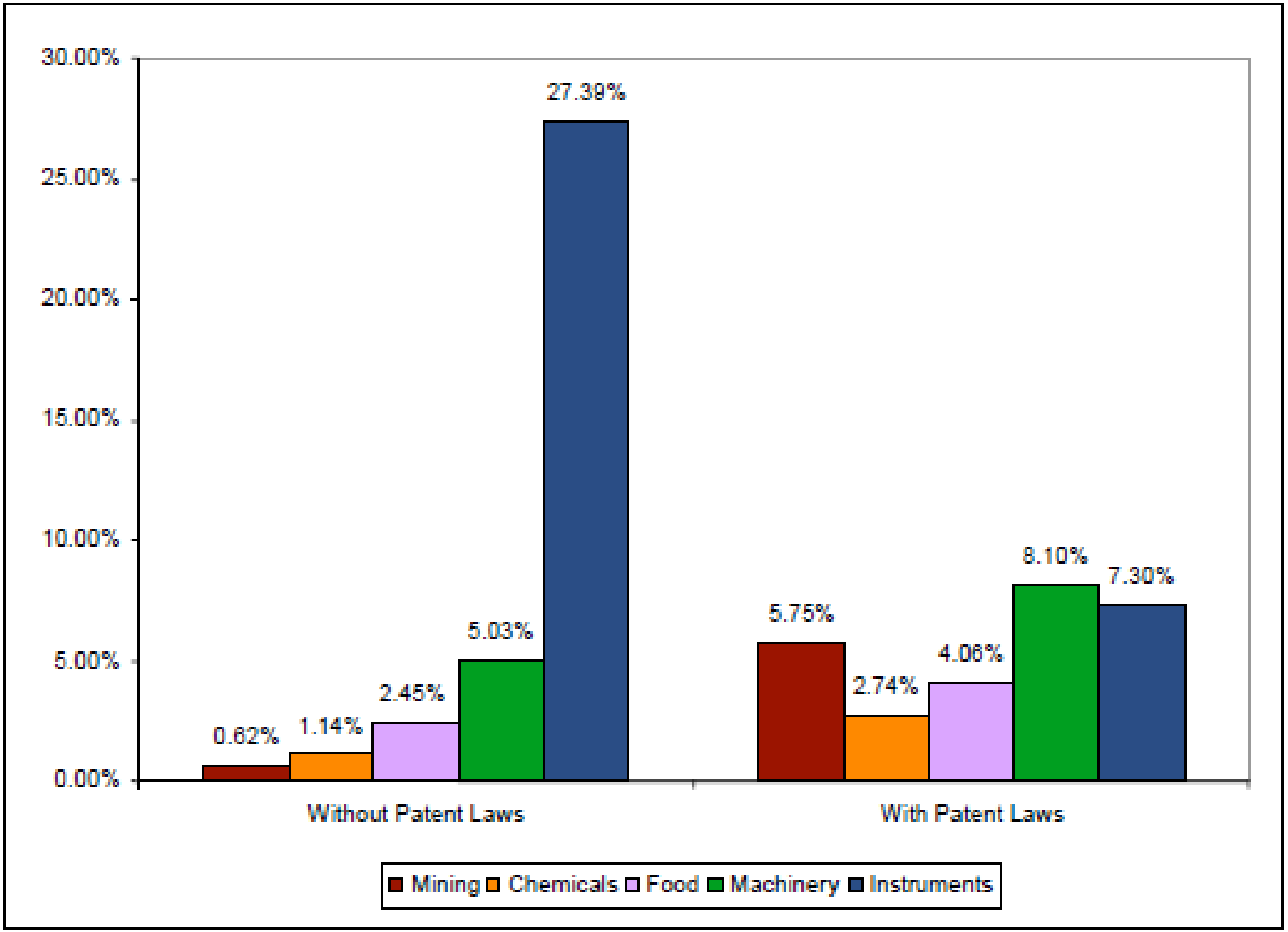
# Multinomial logit to quantify how patent laws influence direction of innovation

- Empirical model for inventors' choice of industry: Multinomial Logit
  - McFadden (1974, 1976)
  - Hausman, Leonard, and McFadden (1995), Haussmann and McFadden (1984)
- Note, these are not causal estimates
- Instead: Are inventors in countries w/o patent laws more likely to choose specific industries?
  - How much more likely?

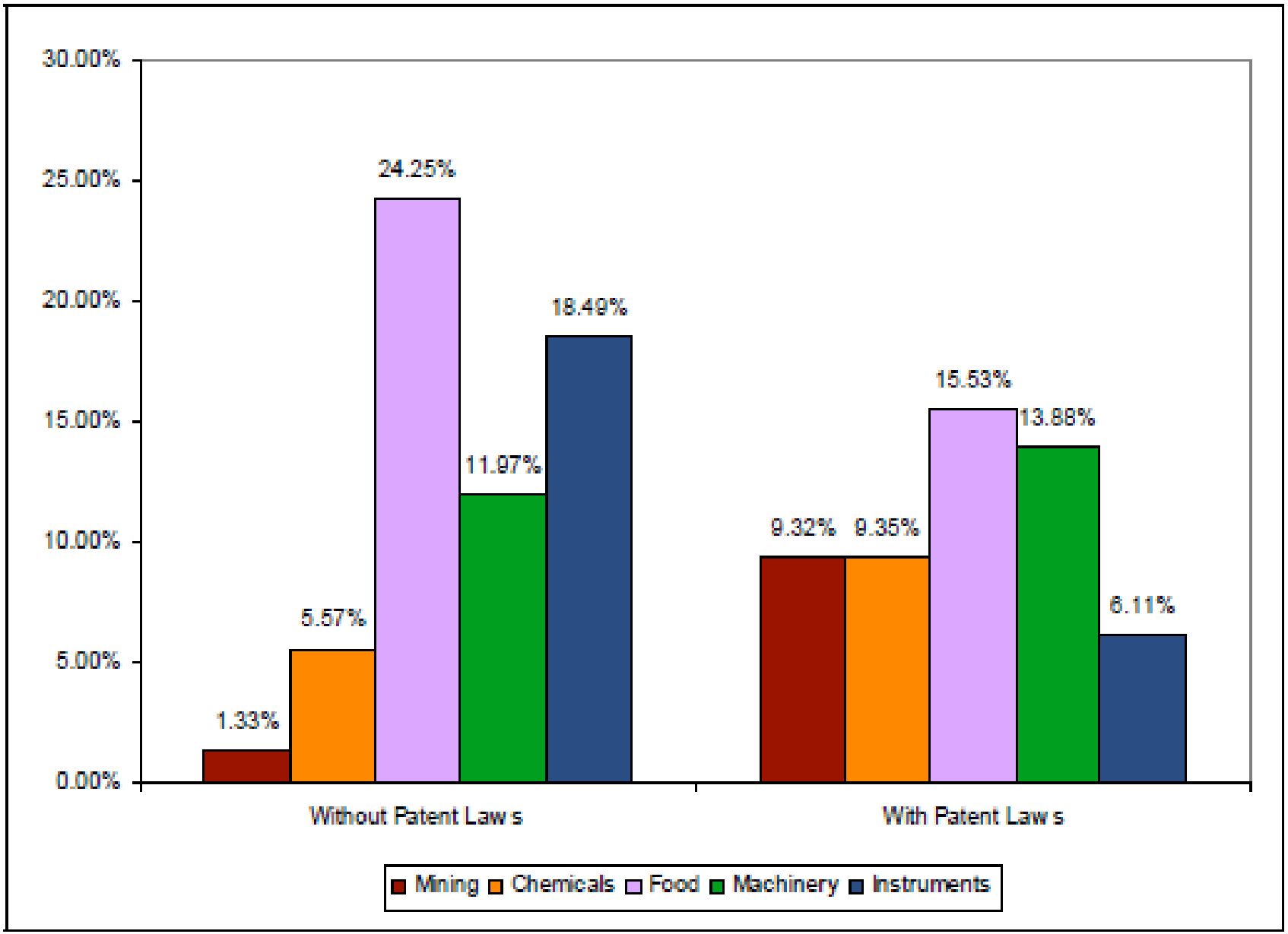
# Multinomial Logit Set Up

- Dependent variable
  - Share of exhibits in 7 industry classes
- Independent variables
  - Dummy variable for “no patent laws” and for “patent length below 10 years”
    - Patent lengths are not continuous
    - Values cluster on 3, 5 and 12, 14, 15
  - Population (in logarithms)
  - GDP per capita
  - Dummy for 1851

# FIGURE 2A – PREDICTED INDUSTRY SHARES IN 1851



# FIGURE 2B – PREDICTED INDUSTRY SHARES IN 1876

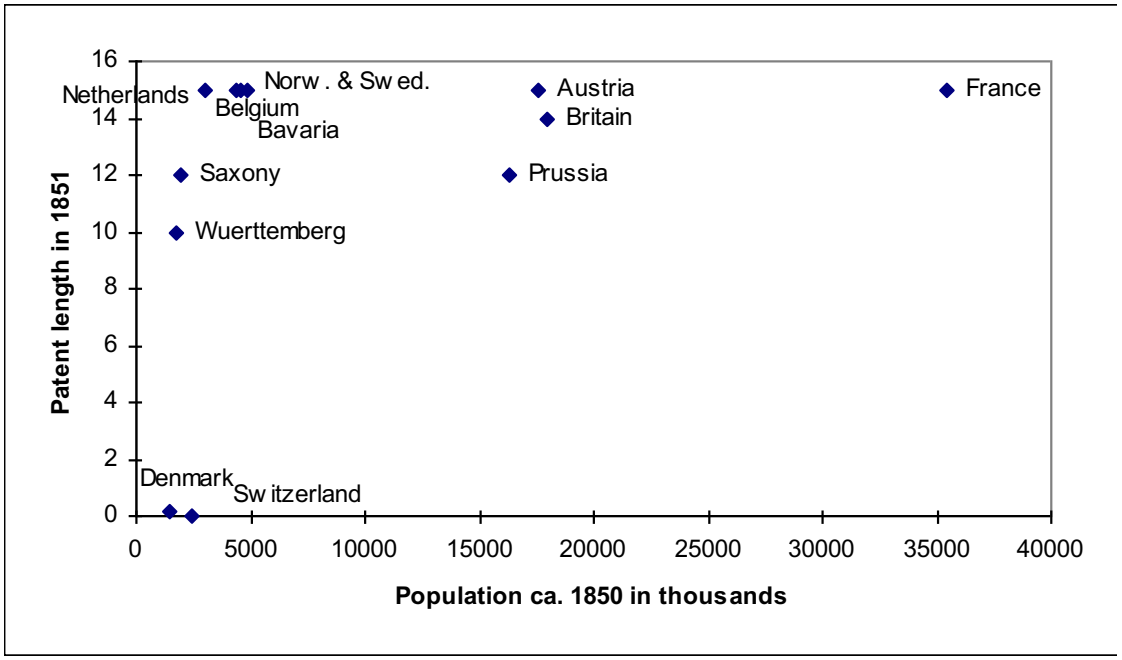



Notes: Predicted values are calculated as $\pi_i(x_{ij}) = \exp(\alpha_i + \beta_i x_j) / \Sigma \exp(\alpha_i + \beta_i x_j)$ from multinomial regressions that control for the logarithm of population and GDP per person (Table 5).

# But are Patent Laws Endogenous?

- Not as endogenous as today
- Early adoptions very fairly ad hoc, and patent laws just grew (Penrose 1951)
  - 1623 English Statute of Monopolies, 1791 French Constitutional Assembly, 1793 U.S. registration system, 1810 Austria, 1815 Russia, 1834 Sweden, 1843 Saxony
- Countries adopted and copied patent laws based on political systems and legal traditions (Lerner 2000)
- Invention “interest” had not awoken just yet

# Denmark and Switzerland were both small countries, w small internal markets

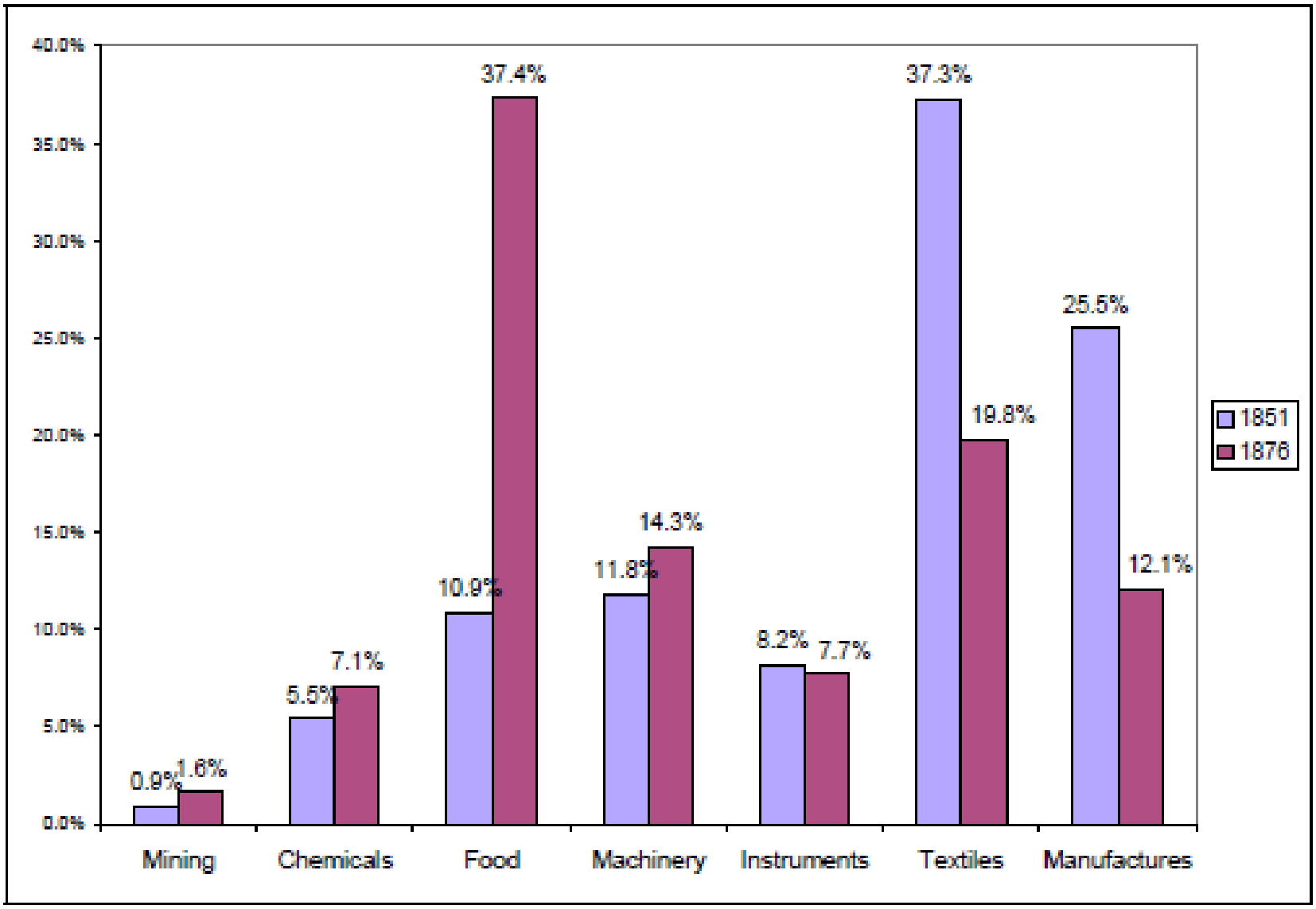



- Benefits from incentivizing domestic invention are low relative to benefits from copying foreign inventions
- Similar tradeoffs for countries that lag behind the technology frontier (Moser, *Pirates and Patents*)
  - Brazil, India, China relative to US today
  - 18th century US textiles relative to Britain
  - 20th century US organic chemistry relative to Germany (Moser and Voena 2012)

# Control for country-specific characteristics

- Netherlands abolish their patent laws in 1869
- After a political victory of the free trade movement
- Free traders opposed patents for idiosyncratic (quasi-random) reasons
  - Patents associated with monopolies
  - Monopolies were associated with restrictions on trade
- What happens to innovation in the Netherlands after the abolition of patents?

# FIGURE 2 – DUTCH INNOVATIONS ACROSS INDUSTRIES BEFORE AND AFTER THE ABOLITION OF PATENT LAWS IN 1869



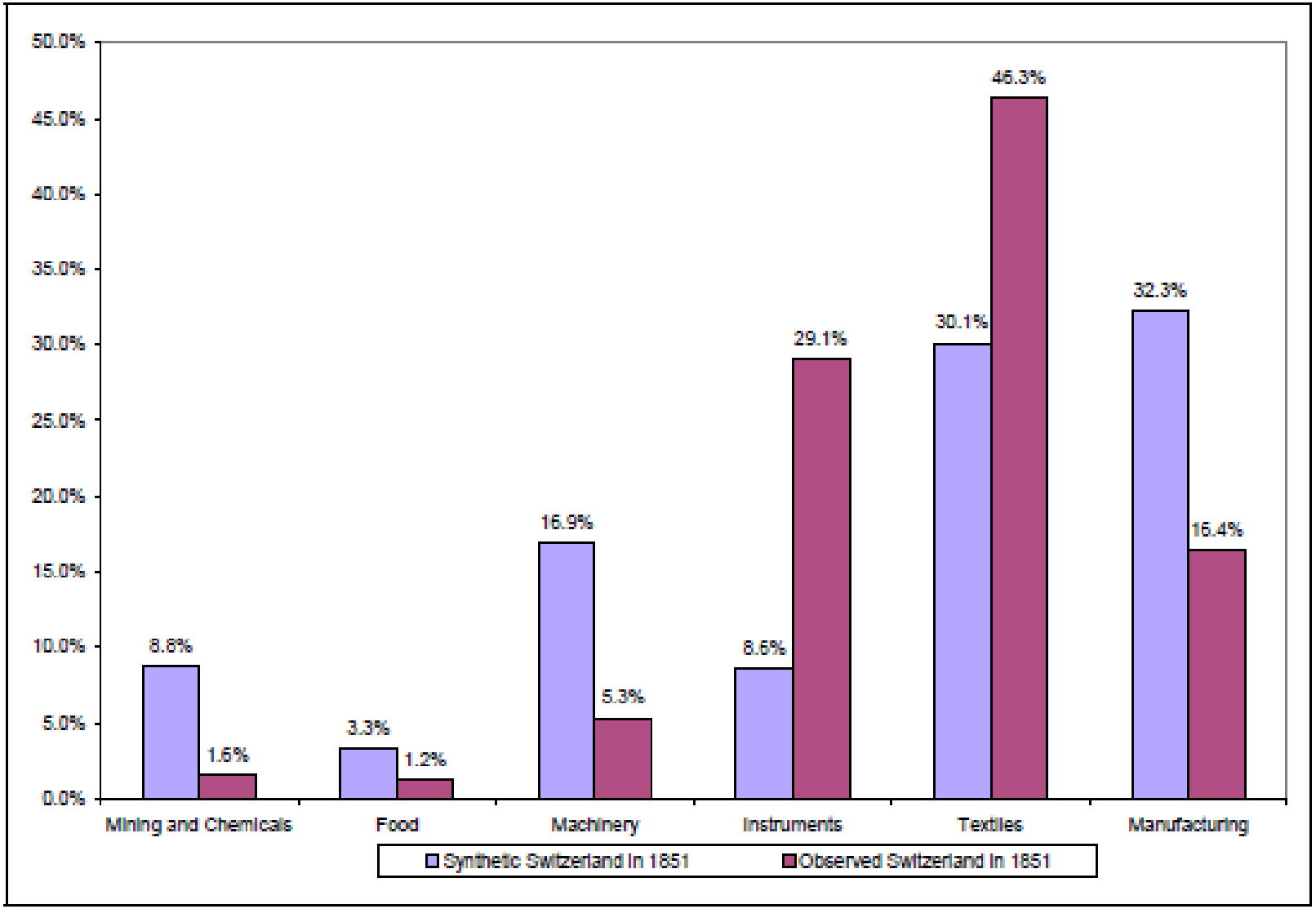

Notes: Calculated from entries in *Official Catalogue* 1851 and United States Centennial Commission 1876

# 19th century innovations in food processing were suitable to secrecy

- Difficult/ impossible to reverse engineer
- Not dependent on patents
- Case study of secrecy in margarine
  - 1869 Mège Mouriès patents margarine (low-end substitute for butter from suet and milk)
  - 1871 Jurgens and van den Bergh adopt the patent in the Netherlands
  - Van den Bergh improves the taste
  - Jurgens cannot copy until 1905
- Note:
  - Food processing and chemistry become vulnerable to secrecy with advances in science in the late 19th early 20th century (Moser J Law Econ 2012)
  - With scientific advances industries shift from secrecy to patents (rarely the other way around)

# Constructing a synthetic Switzerland with patents (propensity score matching using population and GDP)

FIGURE 4 – SYNTHETIC VERSUS OBSERVED SWITZERLAND



# Conclusions

- Patents may fail to raise levels of innovation
  - Alternative mechanisms to protect intellectual property (secrecy)
  - Adoption of foreign technologies
  - Especially important for small and less developed countries (*Pirates and Patents*)
- Patents influence the direction of innovation
  - In the absence of patent protection, inventors and entrepreneurs move toward industries that do not need patents to protect investments in R&D
  - Secrecy is an effective alternatives to patents (Moser 2012)
  - Scientific instruments in the 1850s
  - Direction determines comparative advantage and trade across countries