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

Petra Moser (American Economic Review, 2005)

What Are the Effects of Patent Laws on Innovation?

- Designed to influence innovation, but we don't know exactly how
- 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 From the 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

Do Patent Laws Influence the Direction of Innovative Activity?

- Inventors 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
- 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 the 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
  - System of registration

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

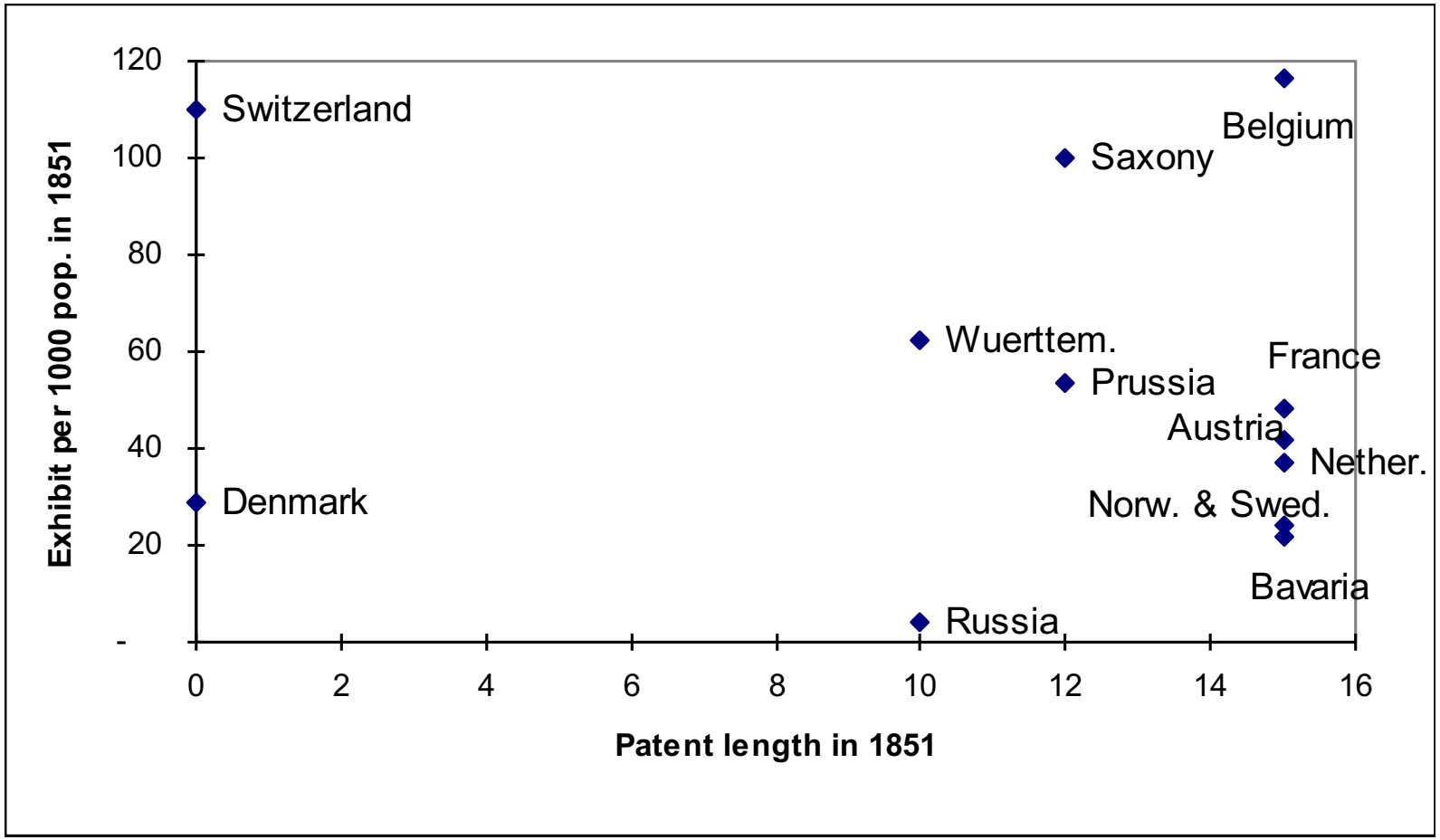
Exhibition	Year	Location	Countries		Exhibitors	
			Total	N.Europe	Total	N.Europe
Crystal Palace	1851	London	40	12	13,876	11,610
Centennial	1876	Philadelphia	35	10	30,864	6,482

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



Regressions of Count Data

- Poisson regression model
  - Given a vector of regressors $\mathbf{x_i}$,
    y_i is independently Poisson distributed with density
    $f(y_i | \mathbf{x_i}) = \exp(-\mu_i)\mu_i^{y_i} / y_i!$ $\quad y_i = 1, 2, 3, \ldots$
    and mean parameter $-\mu_I = \exp(-x_i'\beta)$
  - This implies equidispersion:
    $E[y_i | \mathbf{x_i}] = Var[y_i | \mathbf{x_i}] = \exp(\mathbf{x_i}'\beta)$
- But log-likelihood tests indicate overdispersion
- Negative Binomial
  - General variance function $Var[y_i | x_i] = \mu_i + \alpha \mu_i^p$

Negative Binomial Regressions of Exhibits on Country Characteristics

	Total Exhibits				"Award" Exhibits	
	[1]	[2]	[3]	[4]	[5]	[6]
No Patent Laws	-1.78*** (0.56)	-0.23 (0.41)	-1.28 (0.44)	-0.43 (0.34)	-1.86*** (0.99)	0.20 (0.86)
Short Patent Grants	-1.34*** (0.63)	0.16 (0.45)	-0.84 (0.50)	-0.28 (0.48)		
Population (in log form)		0.98*** (0.16)		0.73*** (0.14)		1.06*** (0.25)
GDP Per Capita				-0.36 (0.32)		0.01 (1.03)
Host Country			2.36*** (0.80)	2.04*** (0.61)		1.09 (1.12)
Crystal Palace				-0.48 (0.41)		
Constant	6.97*** (0.26)	-2.33*** (1.45)	6.47*** (0.21)	0.75 (1.47)	6.03*** (0.41)	-4.17 (2.72)
α	0.98	0.41	0.60	0.25	1.65	0.45
LR test	8.36***	30.92***	21.36***	42.83***	2.15	21.33***
Log-Likelihood	-164.20	-152.92	-157.70	-146.96	-79.56	-69.98

Patent Laws May Fail to Raise Levels of Innovative Activity

- Encourage patentable domestic invention
- Ignore alternative sources for domestic innovation
  - Foreign inventions (Schiff 1971, Dutch adoption of margarine)
  - Alternative means to protect intellectual property (Cohen, Nelson, and Walsh 2000)

Do Patent Laws Help to Explain Differences in Distribution?

- 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

Differences in the Distribution of Exhibits across Industries

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

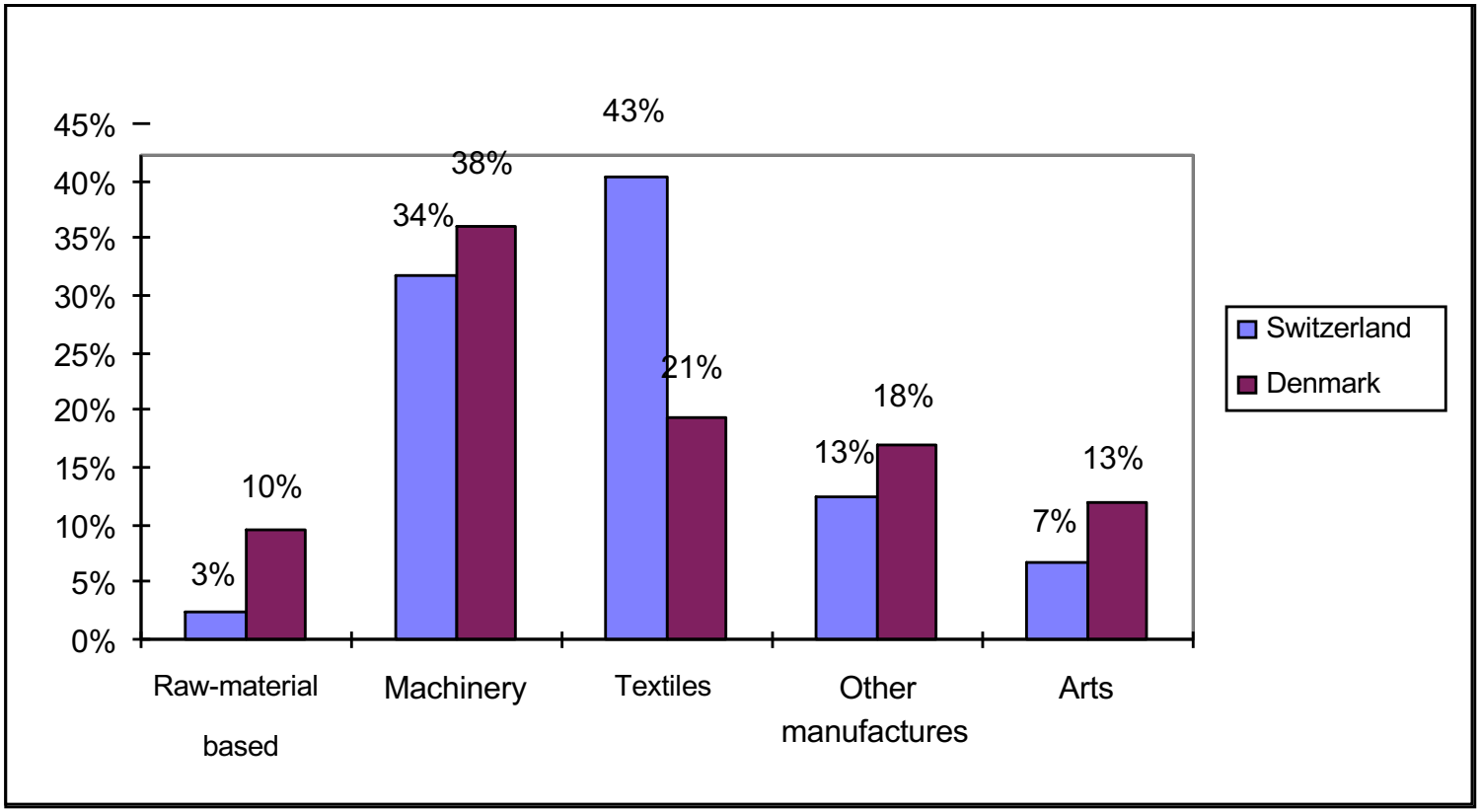
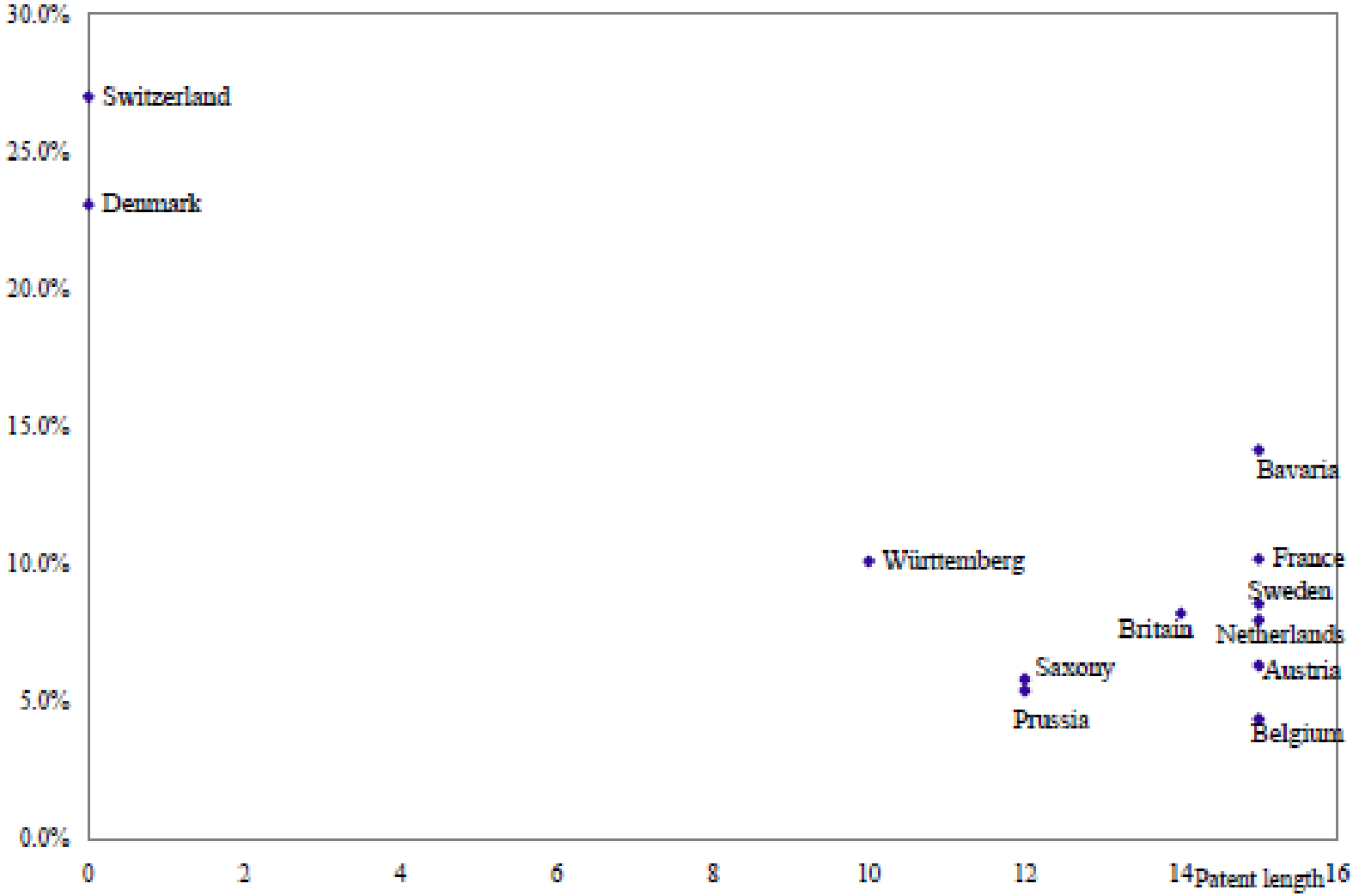


FIGURE 1 – SHARES OF EXHIBITS IN SCIENTIFIC INSTRUMENTS AGAINST PATENT LENGTH IN 1851



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).

Scientific Instruments Are Less Likely to Depend on Patenting

- Astronomical clocks, watches, optical lenses, barometers, theodolites,...
- Innovations depend on skill and detailed knowledge of production processes
- Difficult to reverse-engineer
- Suitable for secrecy

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
- Vallee de Joux 1823-1840
  - Agree not to take apprentices to protect sonnerie des minutes

Patenting Rates Vary Widely Across Industries

Proportion of exhibits that refer to patents for all 4099 English exhibits in 1851	
Industry Class	**Patenting rates**
Mining	4.81%
Chemicals	11.84%
Food processing	9.68%
Scientific Instruments	8.63%
Machinery	22.48%
Machines for direct use, incl. carriages, railways and marine mechanism)	28.57%
Manufacturing machines and tools	38.67%
Civil engineering, architecture, building contrivances	14.57%
Naval architecture, military engineering, guns, weapons	15.54%
Machines, implements and processes of agricultural manufacture	23.44%
Manufactures	12.76%
Textiles	8.23%
Art	6.75%
Total	12.61%

Even quality-adjusted, machinery has the highest patent rates

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%

How Can We Quantify Effects on the Direction of Innovation?

- Multinomial Logit regressions
  - McFadden (1974, 1976)
  - Hausman, Leonard, and McFadden (1995)
- Effects of country characteristics on inventors' choice of industry
- Independence of irrelevant alternatives
  - Haussmann and McFadden (1984)

Multinomial Logit Regressions

- 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

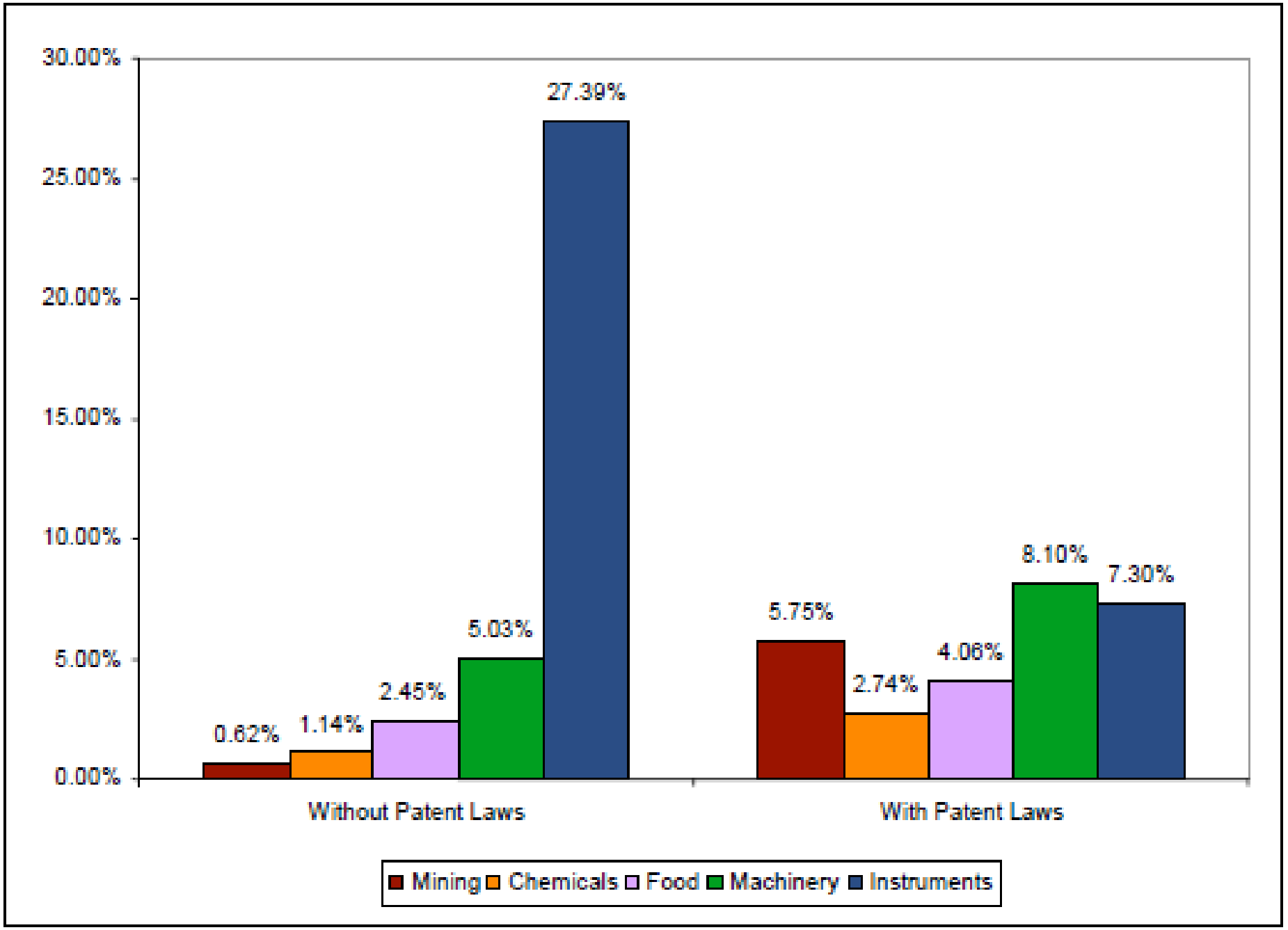
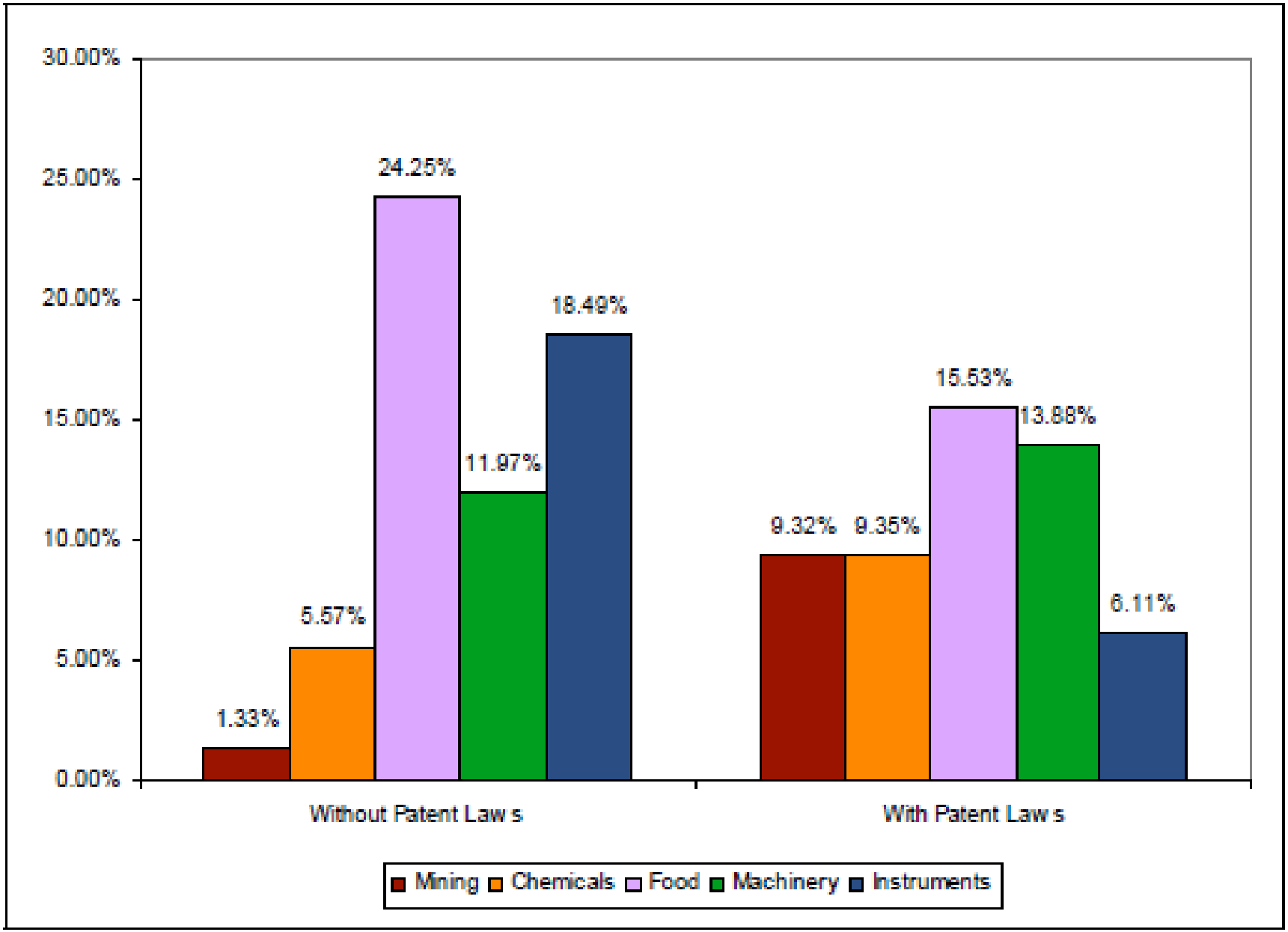
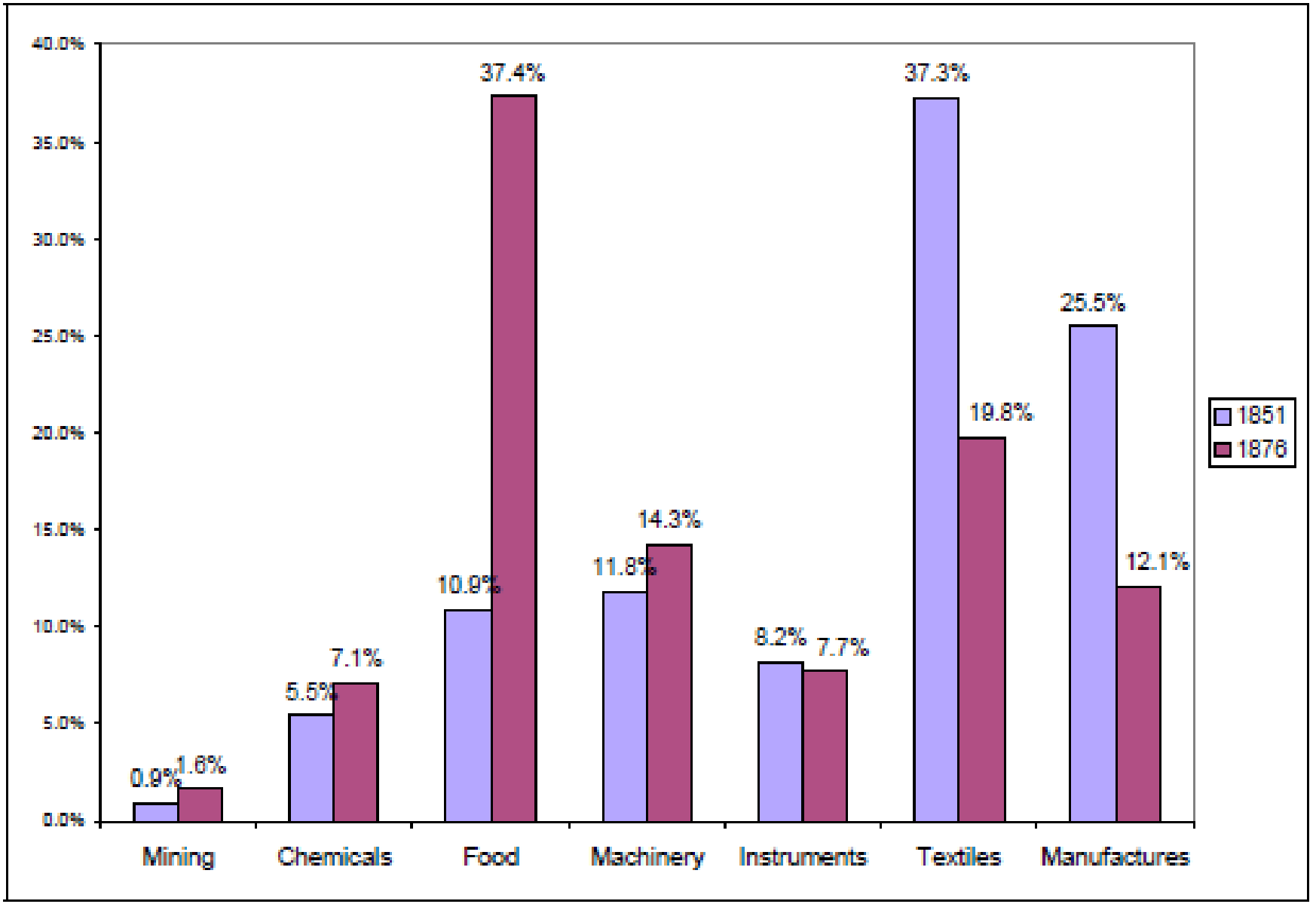


FIGURE 2B – PREDICTED INDUSTRY SHARES IN 1876



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).

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

Patenting and the failure of secrecy in manufacturing machinery

- 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

Secrecy in food processing

- 1869 Mège Mouriès patents margarine
  - low-end 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

Are Patent Laws Endogenous?

- Early patent laws adopted long before 1850
  - 1623 English Statute of Monopolies, 1791 French Constitutional Assembly, 1793 U.S. registration system, 1810 Austria, 1815 Russia, 1834 Sweden, 1843 Saxony
- Early patent laws just grew (Penrose 1951)
- Political systems and legal traditions (Lerner 2000)

Are Small Countries Less Likely to Adopt Patent Laws?

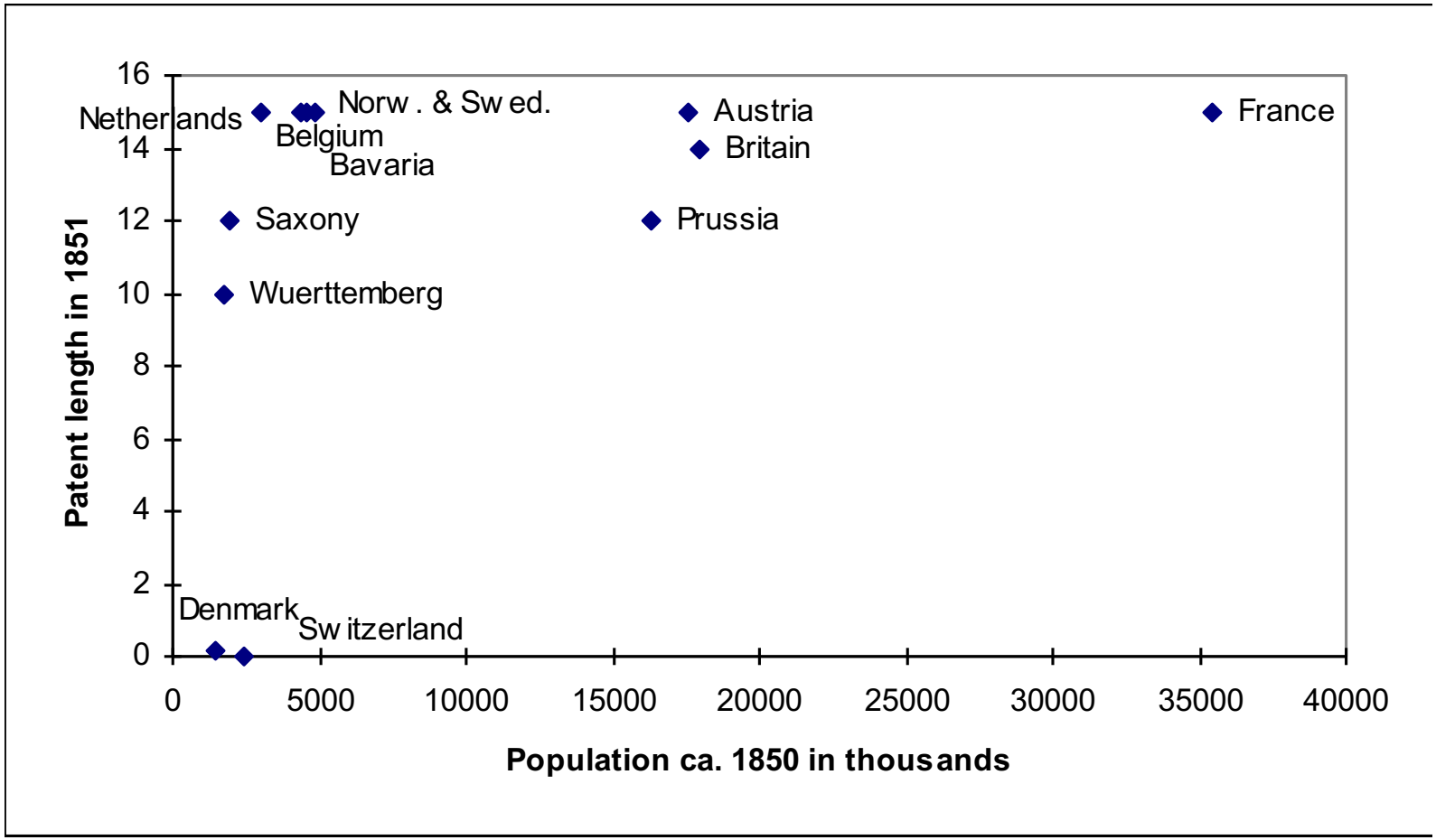
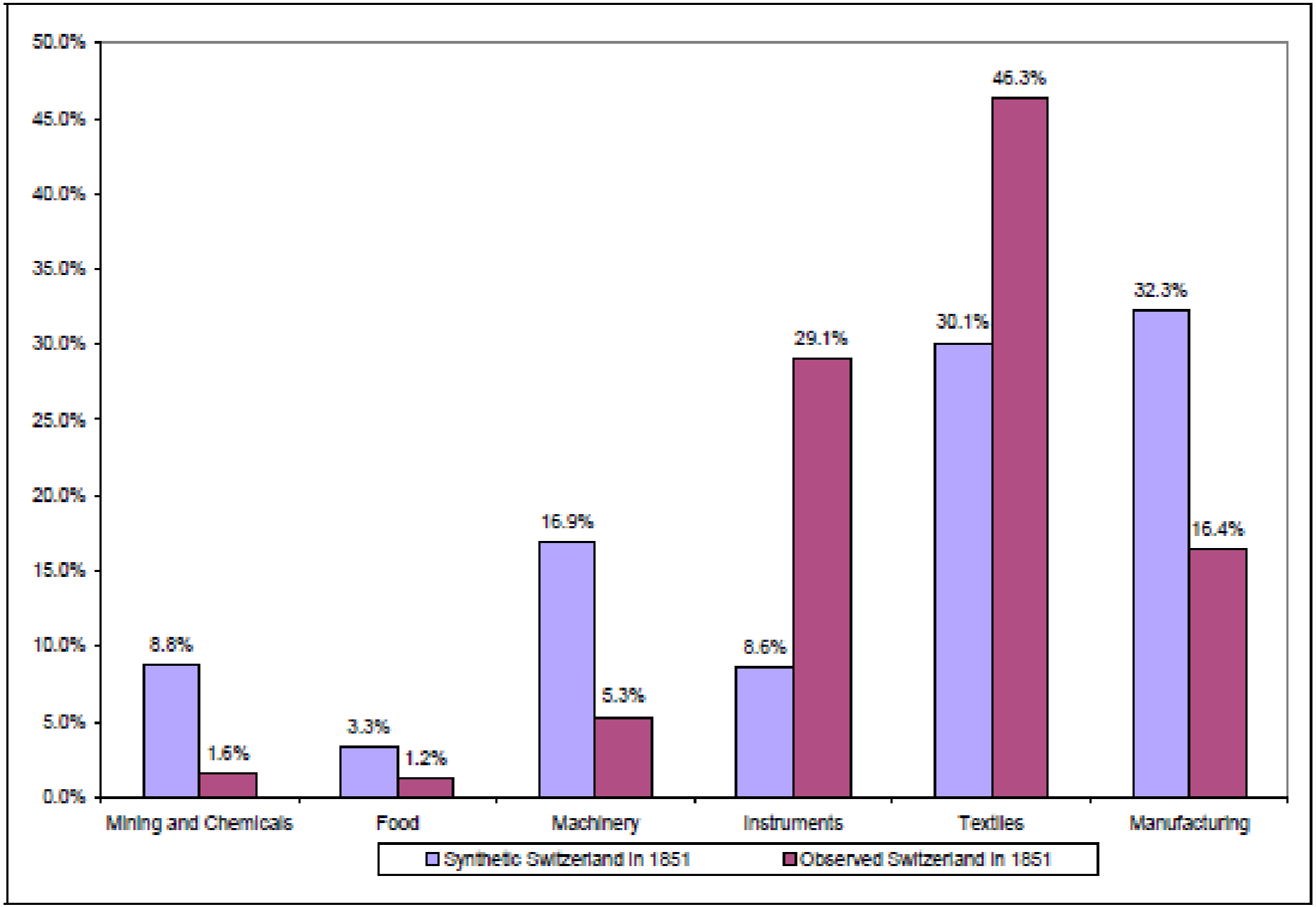


FIGURE 4 – SYNTHETIC VERSUS OBSERVED SWITZERLAND



Conclusions (1/2): Patent laws may fail to increase innovation

- Alternative mechanisms to protect intellectual property (secrecy)
- Adoption of foreign technologies
- Especially important for small and less developed countries

Conclusions (2/2): Patent laws influence the direction of innovation

- Weak patent protection guides innovation towards industry where secrecy is effective
  - Towards instruments, food processing
  - Away from machinery, mechanization
- Direction could be equally important for growth as levels