The Responsiveness of Inventing: Evidence from a Patent Fee Reform

Alice Kuegler,

University College London

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The question

Can financial incentives induce inventors to innovate more?

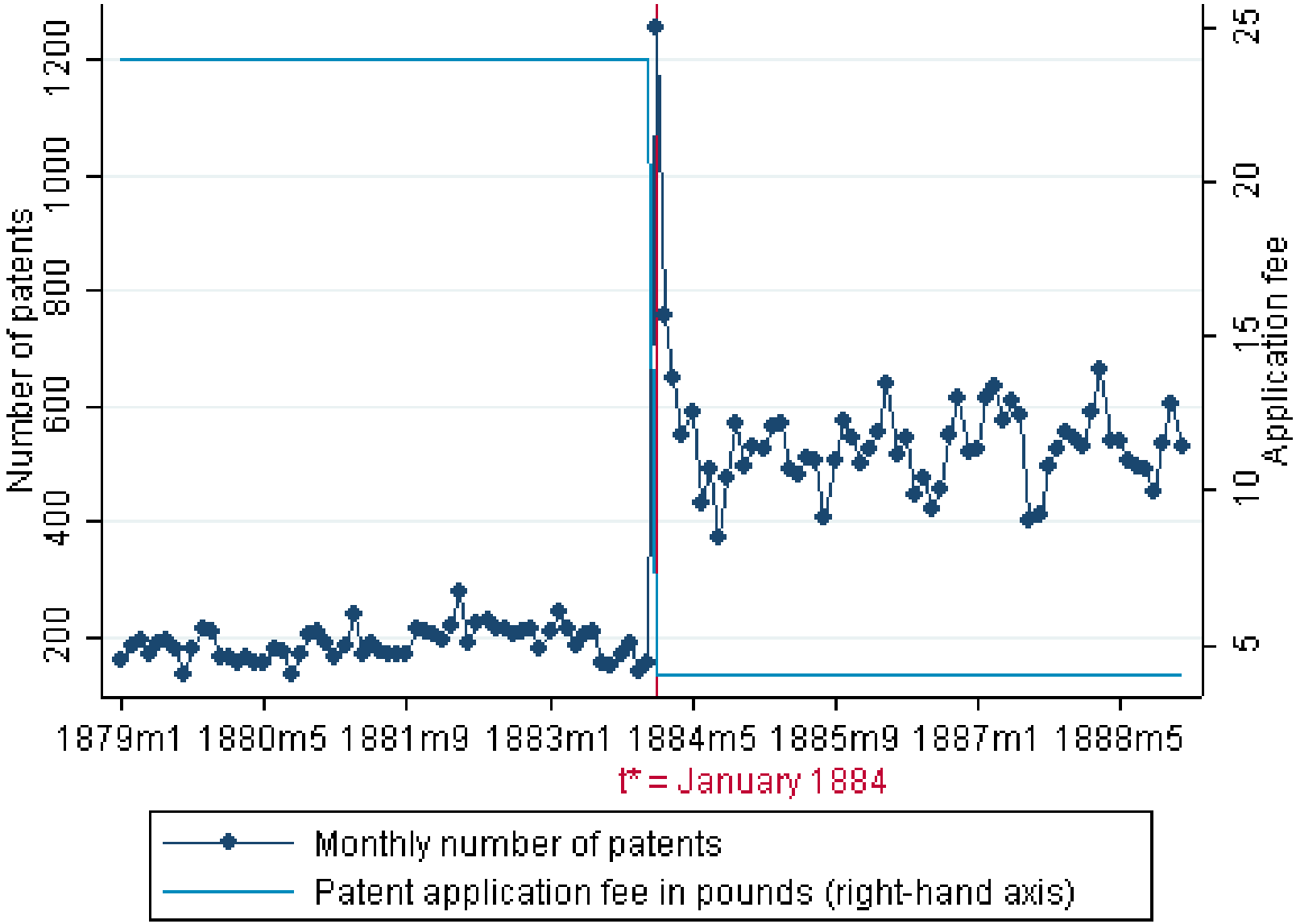
- Inventors are highly skilled contributors to technological progress and growth
- Few studies analyse the behaviour of inventors
- Large efficiency effects if inventors are highly responsive
- Credit constraints as an impediment to inventive activity

Empirical implementation

- I exploit a large reduction in the patent fee in Britain in 1884 that lead to a marked increase in patenting
  - Identification of the effects at the fee discontinuity
- Creation of a new dataset of 54,000 inventors from patent specifications and journals of the UK Patent Office
  - Information on each granted patent for 1879-1888, a ten-year window around the 1884 reform
  - Patent quality measures are constructed from patent renewals
  - Wealth proxy measures are derived from demographic details available for each patentee

▸ Patent specification

Short-run bunching and a longer-run level effect



Are credit constraints important?

Creation of two proxy measures for inventor wealth:

(1) **Ranking inventor surnames by wealth**: constructed from surname probate likelihood at the county-level, following Clark and Cummins (2015) and using data from the National Probate Calendar

(2) **Employment of servants in the household**: obtained by matching inventor names in British census data with an algorithm based on inventor names and addresses

Findings

1. High-quality patents increase in response to the patent fee reduction
    - The **number** of high-quality patents doubles, indicating higher efforts and investment to invent
    - The **proportion** of high-quality patents falls slightly due to a lower quality threshold
2. Credit constraints are important
    - The response is larger for inventors with lower wealth

Overview

- Context
- Conceptual approach
- Estimation and results
- Conclusion

The patent reform in 1884

- The patent fee was lowered by 84% from £ 25 to £ 4 on January 1 1884
  - High pre-reform fee, equivalent to around USD 18,000 in 2018, when deflated by average earnings
  - "A patent in the US is within the reach of every mechanic; in England it is a venture for a capitalist"
  - The pre-reform fee posed "an insurmountable obstacle in the way of the poorest inventors"
- Between 1878-1883 eleven bills relating to patents were discussed in Parliament
- The bill for the Patents, Designs and Trade Marks Act was introduced in February 1883, and legislated in August 1883

Obtaining a UK patent

- A patent fee is payable for the application
- A granted patent can be renewed until a full term of 14 years
- The date of a patent is the date of the initial application

Other reform elements:

- Administrative steps for obtaining a patent reduced
- Period for filing a full patent specification extended from six to nine months
- Extended formalities check of the application structure but no novelty examination
- Renewal fees for patents from 1882 onward stay the same

▸ Renewal fees

Related literature

- **Effectiveness of innovation policy**: Bloom et al. (2002), Bloom et al. (2013), Acemoglu et al. (2013)
- **Entrepreneurship and growth**: Aghion and Howitt (1992), Banerjee and Newman (1993), Aghion and Bolton (1997), Evans and Jovanovic (1989), Hurst and Lusardi (2004), Cagetti and De Nardi (2006)
- **Misallocation of ideas and talent**: Arrow (1962), Akcigit et al. (2015), Hsieh et al. (2013), Bell et al. (2015), Celik (2015)
- **Patenting in nineteenth century Britain**: MacLeod et al. (2003), Nicholas (2011)

Conceptual approach

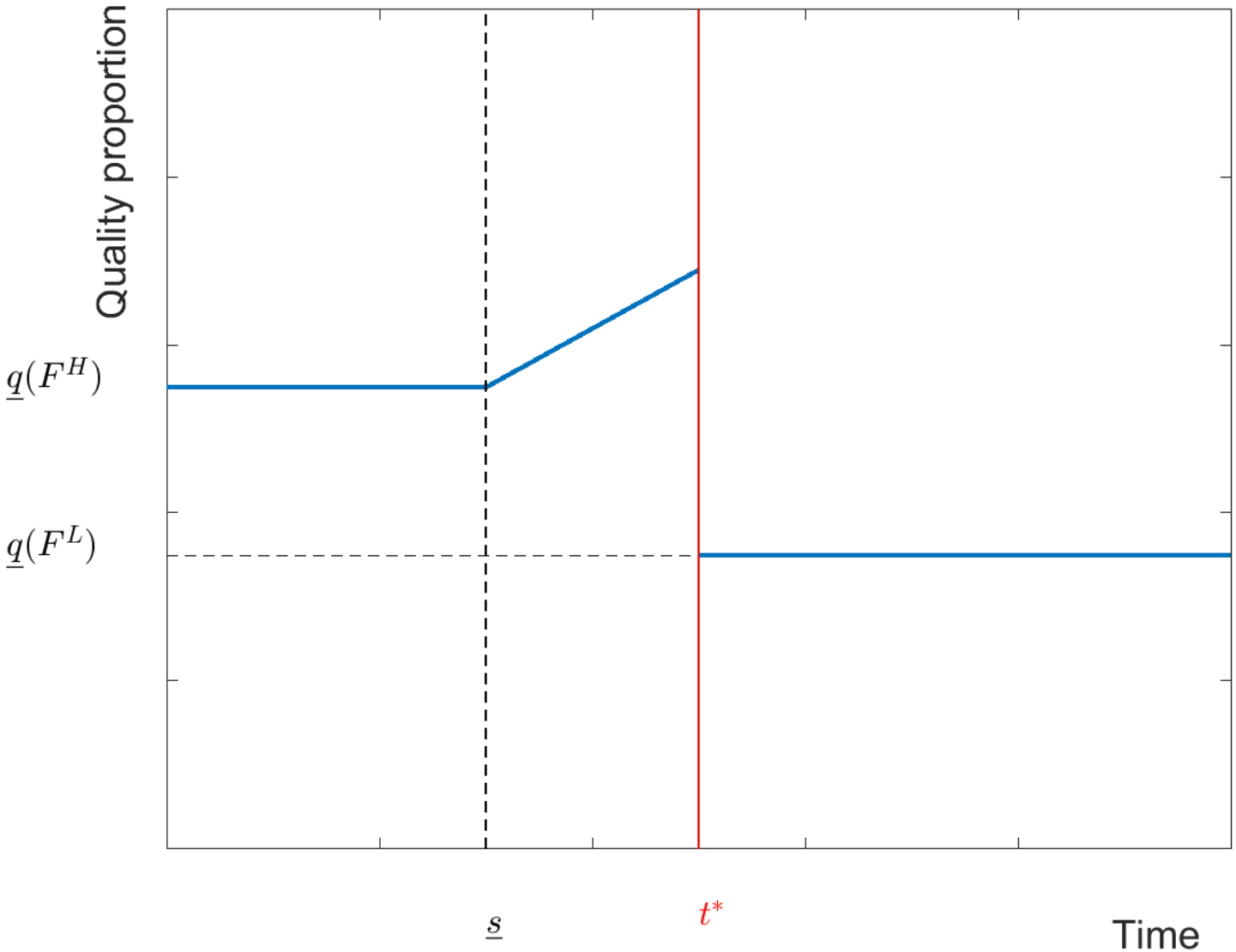
The decision to patent close to a fee drop

- With this anticipated fall in the patent fee, the fee is high, F^H, before the reform in t^* and low, F^L, afterward
- An inventor makes two choices:
  1. When to patent an idea of quality q

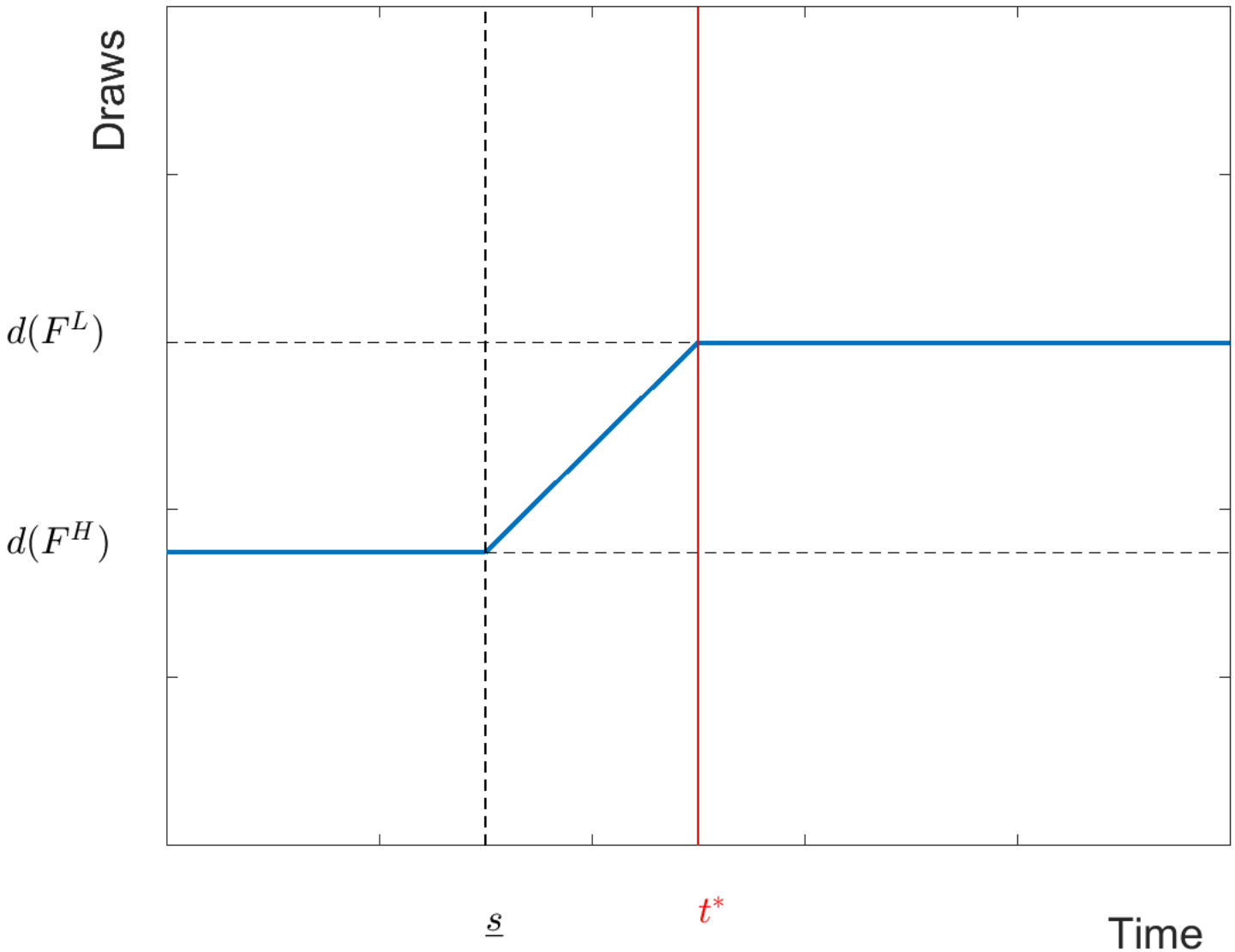
$$\max_t \; U(q, s, t) = (1 - \delta)^{t-s} M(q) - F(t),$$

     where s denotes the time when the idea is conceived, t the time of applying for a patent, δ captures the hazard rate of imitation
  2. How much effort to exert by taking draws d from the quality distribution of ideas

1. The quality selection effect of a patent fee drop



2. The effort effect of a patent fee drop



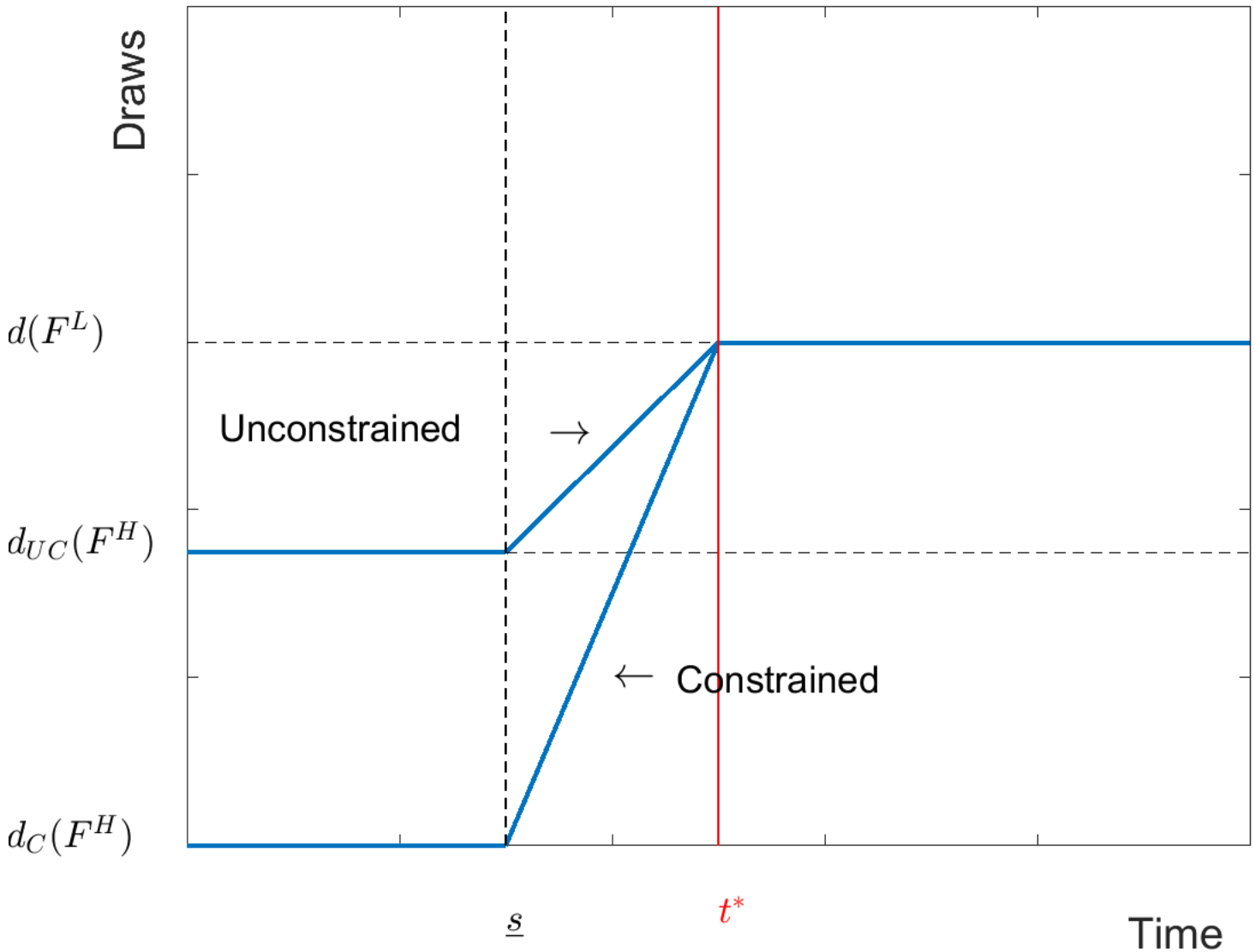
2. The effort effect of a patent fee drop

Predictions:

- The **number** of high-quality patents is higher after the fee decrease.
- The **proportion** of high-quality patents relative to the total number of patents is lower after the fee decrease.

- Comparing the high-quality share of the patenting increase to the pre-reform share of high-quality patents approximates the relative importance of increased effort

The effort effect with credit constraints



Estimation and results

The increase of patent numbers

- In the short run, excess bunching b is given by the difference between observed bunching c_t and a counterfactual distribution $\hat{c}_t$:

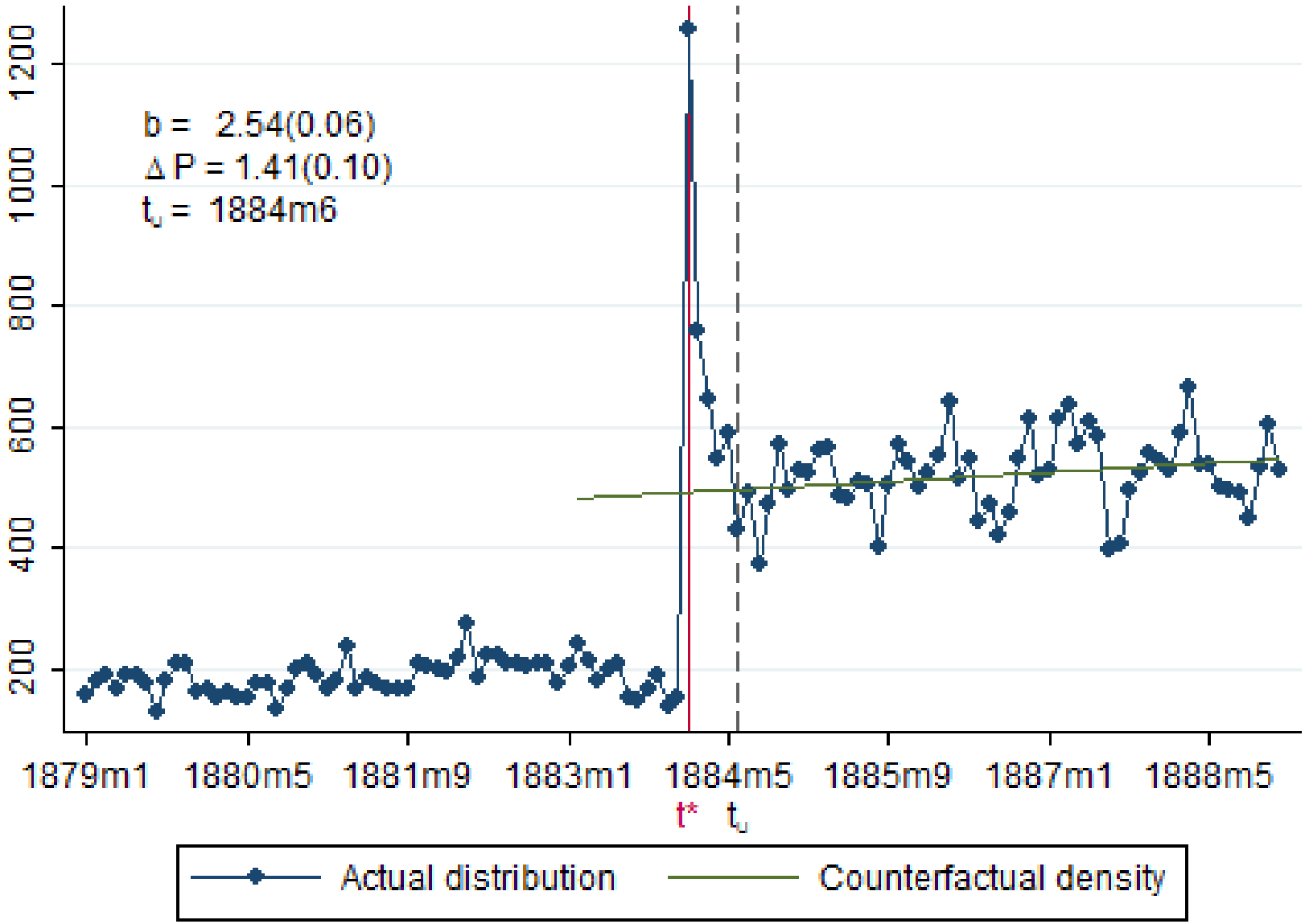
$$b(t_U) = \sum_{i=t^*}^{t_U} (c_t - \hat{c}_t).$$

  - Upper bound t_U is chosen as end point of the bunching

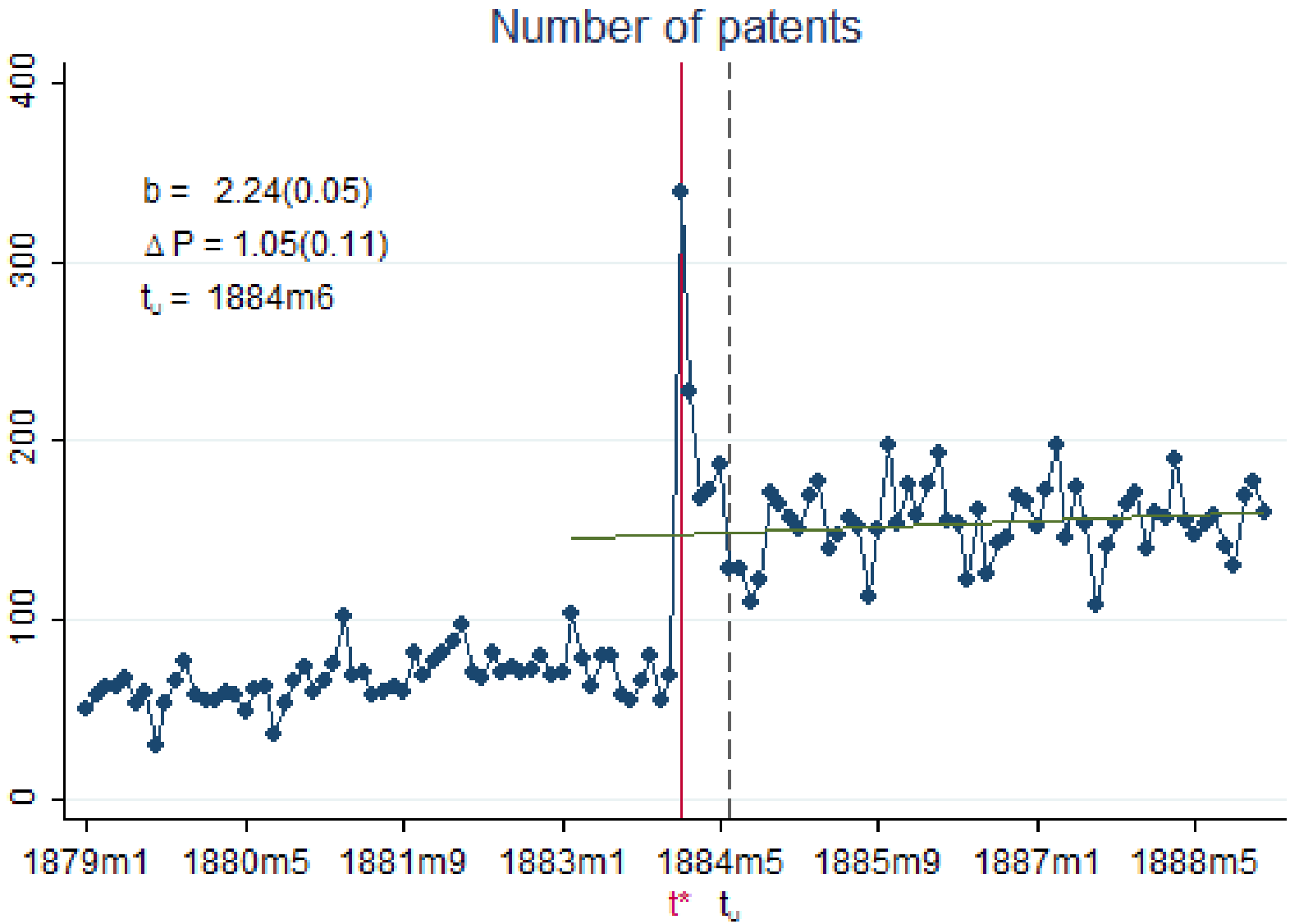
- The longer-run percentage change compares monthly patent numbers in 1885 to 1882:

$$\Delta P = \frac{P_{1885} - P_{1882}}{P_{1882}}$$

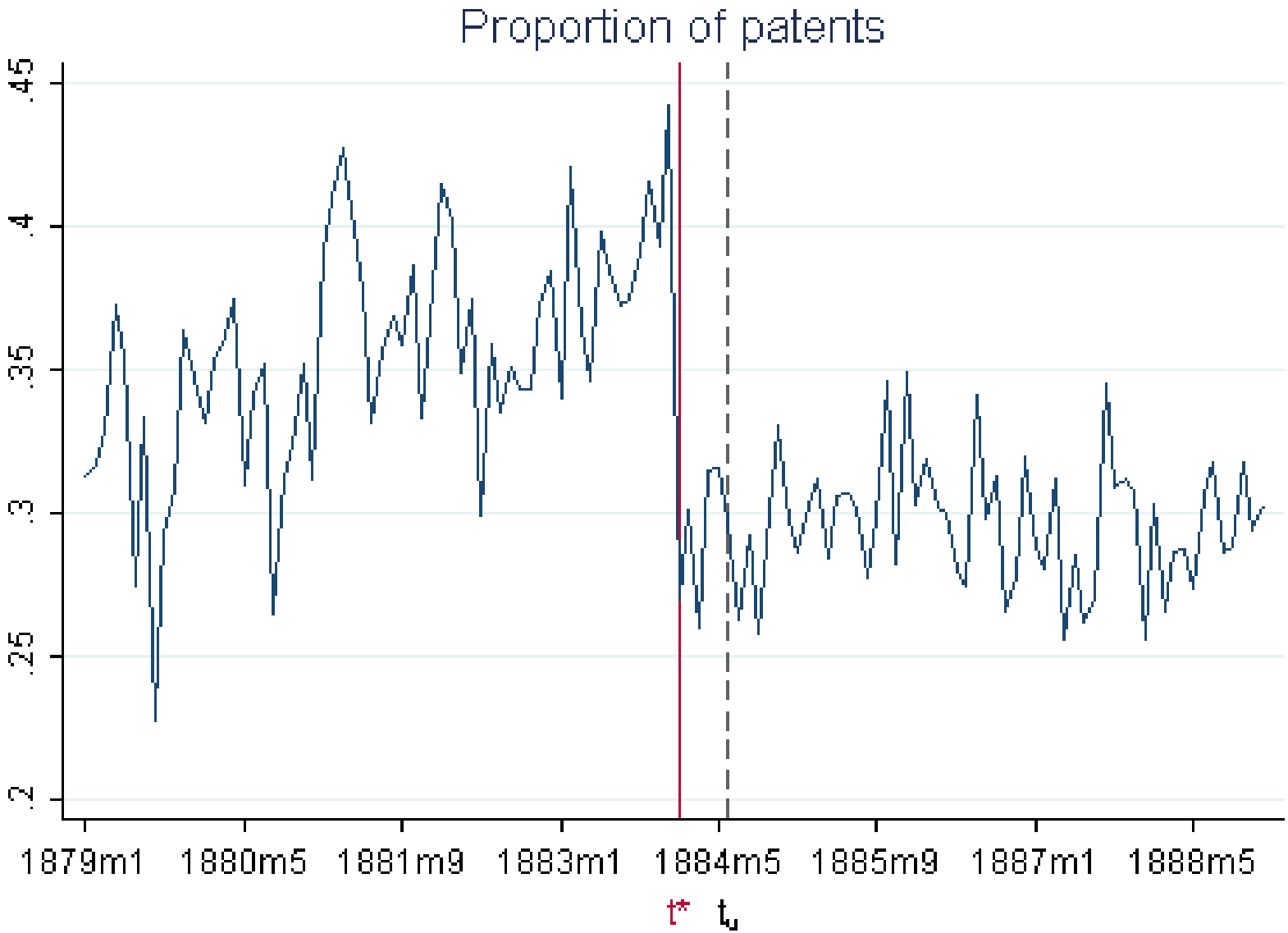
All British patents granted 1879-1888



Patents renewed after four years



Patents renewed after four years



Responses to the 1884 patent fee change

Patent quality	b	e_{SR}	ΔP	ε_{LR}
All patent types	2.54	-3.02	1.41	-1.68
	(0.06)	(0.07)	(0.10)	(0.13)
Granted only	2.67	-3.18	1.62	-1.92
	(0.06)	(0.08)	(0.13)	(0.08)
Renewed after 4 years	2.24	-2.67	1.05	-1.25
	(0.05)	(0.06)	(0.10)	(0.06)
Renewed for 14 years	1.53	-1.82	1.13	-1.34
	(0.08)	(0.10)	(0.19)	(0.13)

Notes: Short-run excess bunching is given by b, e_{SR} denotes the reduced-form elasticity estimated from bunching, $\Delta P = (P_{1885} - P_{1882})/P_{1882}$ is the percentage change in the monthly average number of patents in 1885 compared to 1882, and ε_{LR} gives the longer-run elasticity. Standard errors are reported in parentheses.

Patent quality shares

Patent quality	Share in 1882	Share in 1885	Difference 1985 - 1882	Increase share over 1882 share
Granted only	0.64	0.69	0.73	1.14
	(0.00)	(0.00)	(0.00)	(0.01)
Renewed after 4 years	0.36	0.31	0.27	0.74
	(0.03)	(0.02)	(0.01)	(0.04)
Renewed for 14 years	0.08	0.07	0.06	0.80
	(0.01)	(0.01)	(0.01)	(0.10)

Notes: Share of the increase refers to $(P_{q,1885} - P_{q,1882})/(P_{1885} - P_{1882})$. Standard errors are reported in parentheses.

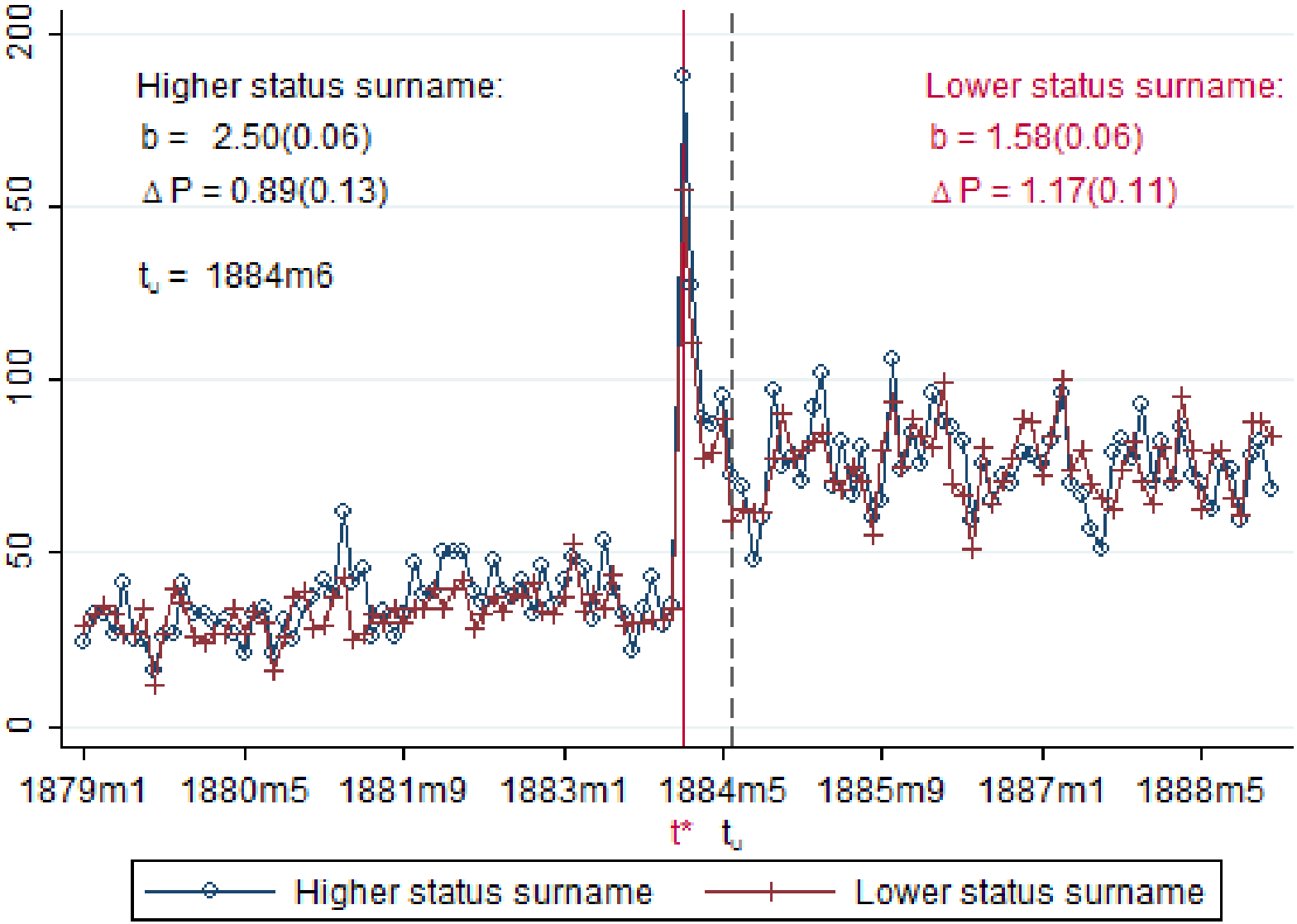
Results for inventors by wealth group

To test for the importance of credit constraints, the sample is grouped into high and low wealth types

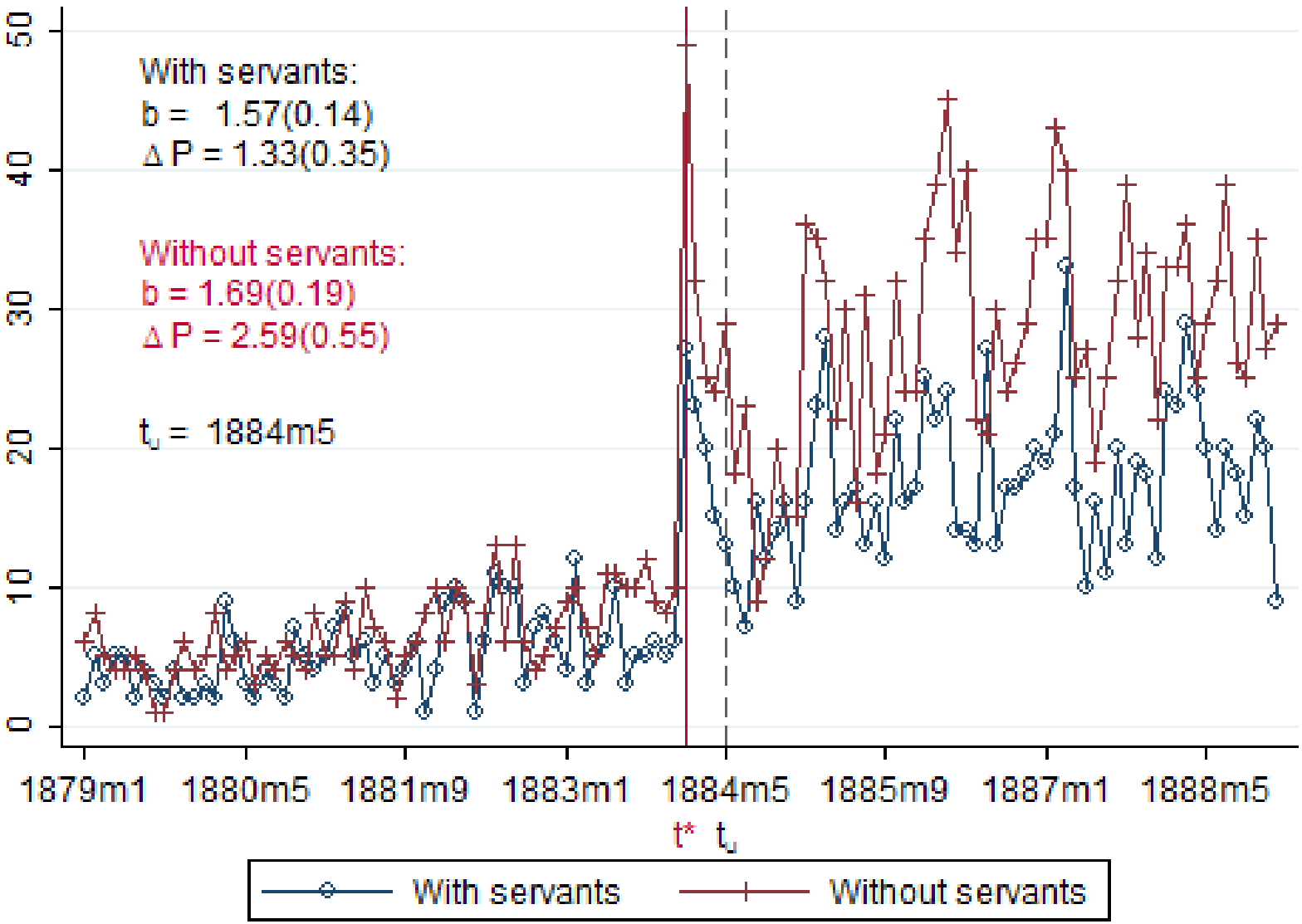
1. Inventors with high/low surname wealth rank ▸ Ranking

2. Inventor households that employ servants

By wealth: (1) renewals by surname wealth status



By wealth: (2) renewals by employment of servants



Conclusion

1. The patent fee reduction lead to a large increase in innovation
   - The number of high-quality patents increases by over 100%, with a longer-run elasticity of -1.25
   - The proportion of high-quality patents declines slightly due to a lower quality threshold
2. Stronger response by inventors with lower wealth
   - Credit constraints matter

- Large potential efficiency impact of innovation policies that reduce the cost of inventing

A.D. 1885, 3rd FEBRUARY. N° 1507.

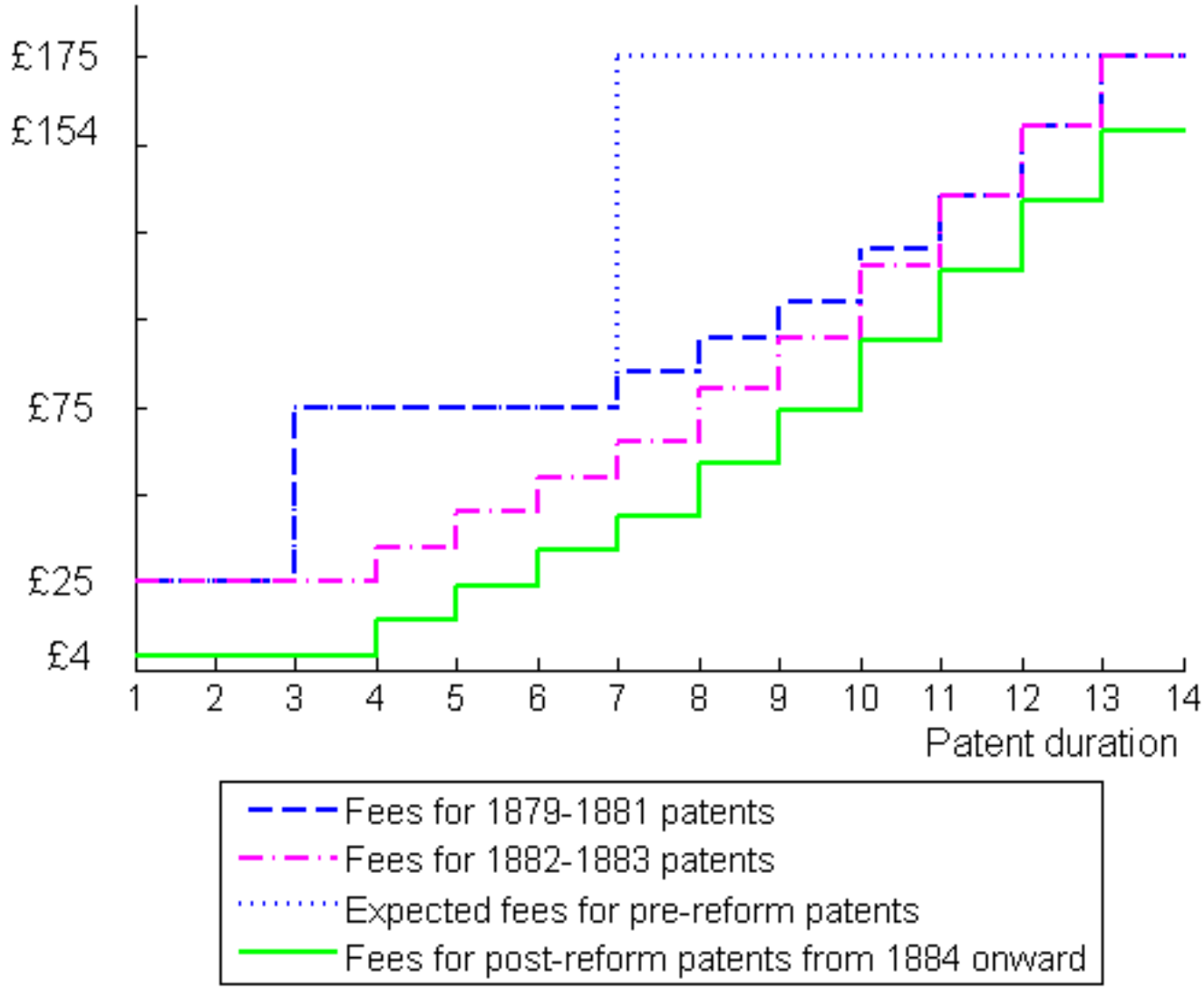
PROVISIONAL SPECIFICATION.

Improvements in Screens or Sieves for Purifying or Sieving Machinery.

I, HENRY SIMON, of N° 20 Mount Street Manchester in the county of Lancaster, Civil Engineer do hereby declare the nature of my invention for "IMPROVEMENTS IN SCREENS OR SIEVES FOR PURIFYING OR SIEVING MACHINERY" to be as follows:—

In purifying or sieving machinery such as is used for sieving pulverulent or granular materials, as in flour milling, sieving or screening surfaces consisting generally of silk or other fabric or wire gauze stretched over frames are generally used, and when these surfaces become worn or defective, it is in many cases difficult to get into the machines to remove them and fix new ones in their place. My present invention relates to an improved construction of the frames and mode of fixing the screening surfaces thereto whereby the latter can be readily removed

Patent application and renewal fees



Ranking inventor surnames by wealth

- Probate was legally required for any estate value at death equal to £10 or above
- Data records of the National Court of Probate
- Surname measure is constructed by using county frequencies of an inventor's surname z:

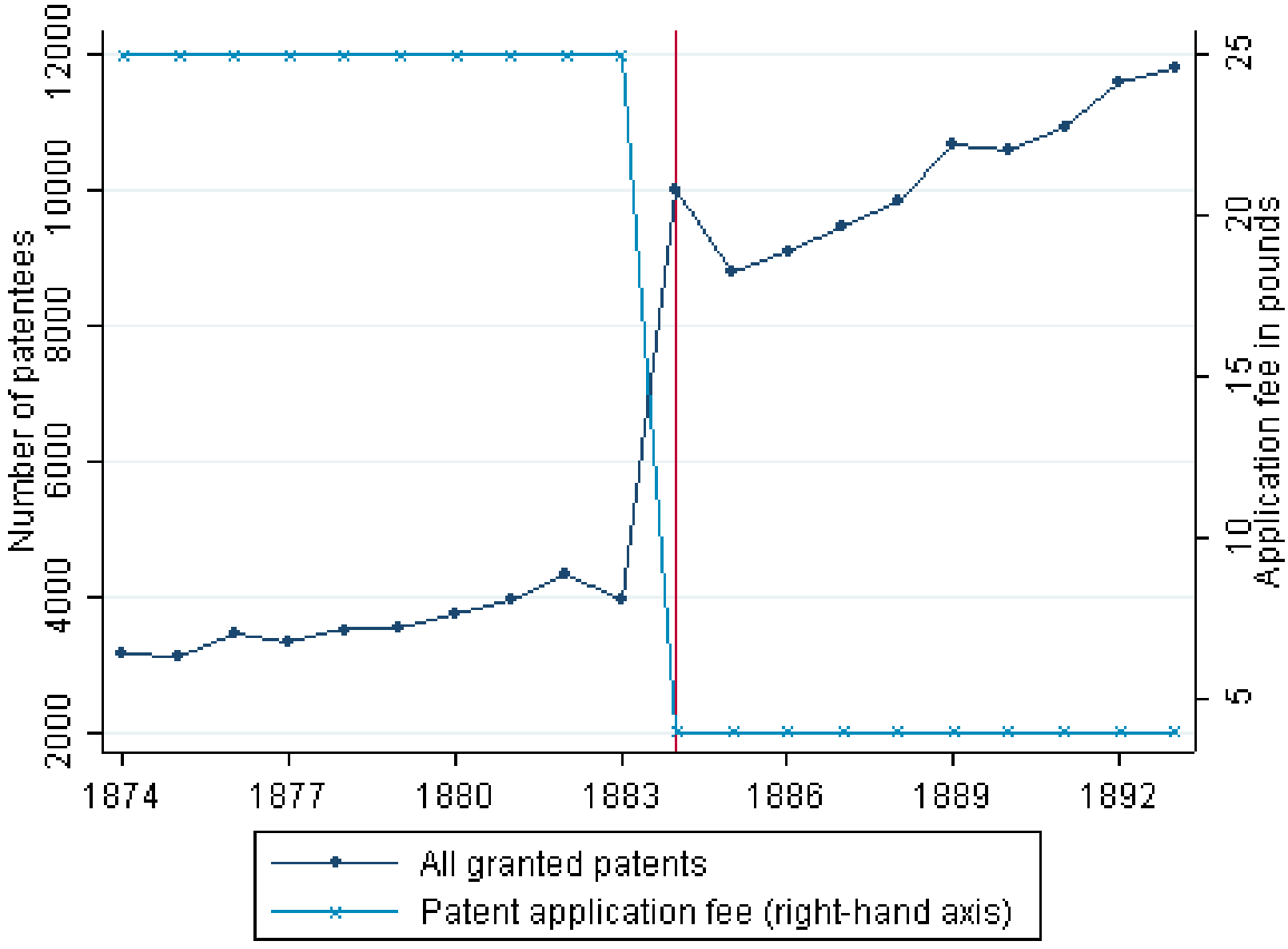
$$\frac{\textit{Share of surname } z \textit{ probated in county } j \textit{ at } T \pm 10}{\textit{Share of surname } z \textit{ in the } 1881 \textit{ census in county } j}.$$

where the time range is defined as 21 years range around T, the year of patenting plus eleven years

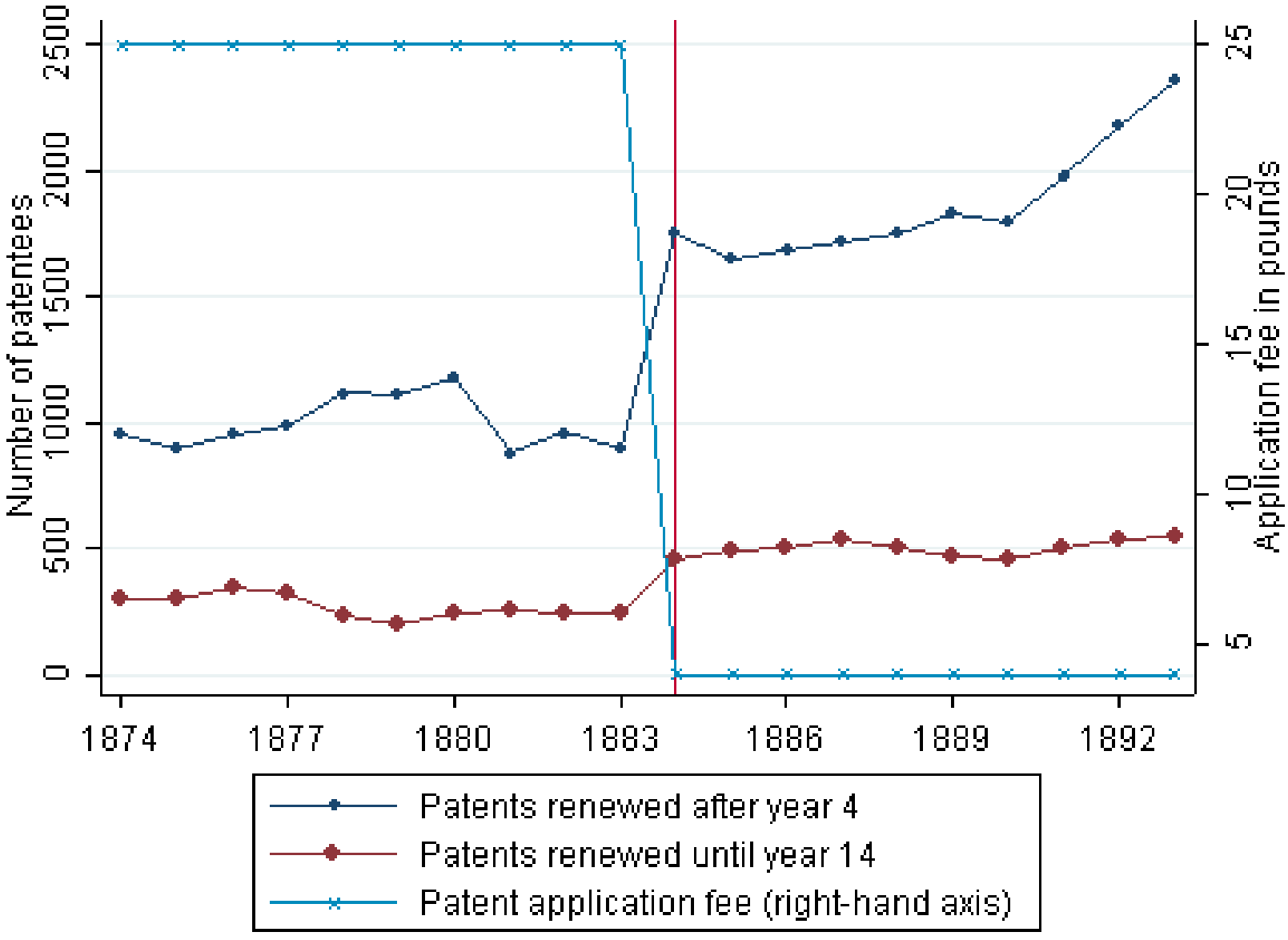
Summary statistics for British patentees

	1879-1888	1879-1882	1885-1888
Number of British patentees	53,873	11,114	31,354
Number of patents by British patentees	42,474	8,822	24,456
Proportion of single inventors	0.61	0.62	0.59
	(0.49)	(0.49)	(0.49)
Share patentees with more than one patent	0.55	0.52	0.55
	(0.50)	(0.50)	(0.50)
Average number if multiple patents per patentee	4.90	4.73	5.04
	(6.85)	(5.96)	(7.24)
Proportion renewed at 4 years	0.31	0.35	0.30
	(0.46)	(0.48)	(0.46)
Proportion of patents renewed at 14 years	0.07	0.06	0.07
	(0.25)	(0.25)	(0.25)
Proportion of patents patented in the US	0.06	0.09	0.06
	(0.25)	(0.28)	(0.23)

UK patents 1874-1893



Renewed UK patents 1874-1893



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