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The impact of novelty examination on the regional distribution of patenting activity in early 20th century Britain

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Abstract

The late 19th-century reforms to the British patenting system reduced the cost of obtaining a patent from over £100 in 1851 to just £4 by 1883. While increasing accessibility, this cost reduction led to an increase of low-quality patents often replicating previous inventions, raising concerns about the system's effectiveness. As a result, the 1902 policy proposed novelty examination for the first time, increasing the cost by 25%. This paper examines whether the implementation of this policy in 1905 had a differential effect on patenting activity across British regions. Despite the significance of this policy, it has received extremely limited academic attention. This research aims to fill this gap and add to the literature on the regional impacts of patent system reforms in this period. This study employs panel regressions using data on every geocoded patent sealed between 1895-1915 in the PatentCity database with regional employment in 28 industries as controls. Results indicate no change in the regional distribution of patenting activity as a result of the novelty examination. These findings are consistent with those of Nicholas (2011) for the 1883 policy and have important implications for the geography of inventive activity and the distributional impacts of invention policies.

Section 1: Introduction

Prior to reform in 1852, obtaining a patent was a slow and expensive process, costing over £100, equivalent to a skilled workers annual wage.[1] The high cost excluded many inventors with valuable inventions, hence most invention occurred outside the patenting system, through collective invention processes.[2] The 1852 reforms reduced these costs to £25, and later to £4 in 1883, leading to

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[1] Christine MacLeod et al., "Evaluating Inventive Activity: The Cost of Nineteenth-Century UK Patents and the Fallibility of Renewal Data," *The Economic History Review* 56, no. 3 (August 1, 2003): 537–62, https://doi.org/10.1111/j.1468-0289.2003.00261.x. page 541

[2] Stephen Van Dulken, *British Patents of Invention, 1617-1977: A Guide for Researchers* (British Library Science Reference & Information Service, 1999). Page 5 ; Khan Zorina and Kenneth Sokoloff, " Historical Perspectives on Patent Systems in Economic Development," in *The Development Agenda: Global Intellectual Property and Developing Countries* (New York: Oxford Academic, 2008).page 221 ; MacLeod et al. 2003, "Evaluating Inventive Activity," Page 539

surges in patenting activity, a significant proportion of which was low-value and anticipated by prior art.[3] Consequently, to prevent the patenting of low-value inventions and eliminate duplication that had previously inflated recorded inventive activity by 25-42% in the late 19th century, the 1902 policy introduced novelty examination into the patenting process, requiring patentees to pay an additional £1.[4]

Through incentivising inventors with high-quality inventions that previously didn't use the system due to fear of infringement, and discouraging those with low-quality inventions anticipated by prior art, the policy should have resulted in the patenting of overall higher-quality inventions. The increased cost, equivalent to over £100 today, may however have prevented credit-constrained inventors from using the system.[5] Given the critical role of invention in economic growth, analysing policies that alter inventors' incentives to use the patent system at the regional level is essential. Such policies can influence regional inequalities in both inventive activities and subsequent economic development. Despite its significance, this policy has received extremely limited academic attention. This research aims to fill this gap.

This paper investigates whether the introduction of novelty examination resulting from the 1902 policy change impacted the distribution of patenting activity across regions. By utilising novel geocoded patent data on domestic inventors 1895-1915 from the PatentCity dataset and employment data from 28 industries within each region as controls, I employ panel and linear regression techniques. I supplement this analysis with reports from the Comptroller of the Patents, Designs and Trademarks Office (1852-1915) and data on the occupations of inventors from the PatentCity dataset. My findings indicate, contrary to potential expectations that such a cost increase might alter regional

[3] Van Dulken 1999, *British Patents*, Pages 2, 5, 25
[4] Khan and Sokoloff 2008, "Historical Perspectives," Page 221; Van Dulken 1999, *British Patents*, Page 5; MacLeod et al. 2003, "Evaluating Inventive Activity," Page 548
[5] "Inflation Calculator," Bankofengland.co.uk, 2025, https://www.bankofengland.co.uk/monetary-policy/inflation/inflation-calculator

patterns, the implementation of the 1902 policy had limited regional impact and did not alter the pattern of patenting activity at the regional level. This has important implications for the distributional effects of policies and the persistently unequal distribution of inventive and aggregate economic activity across British regions.

The paper proceeds as follows: Section 2 provides historical background of 19th and 20th century patent reforms, discusses the relevant literature, and presents theoretical predictions. Section 3 introduces the sources used and Section 4 discusses the methodology used to analyse the data. Section 5 presents results, including descriptive patterns and regression analysis. Section 6 discusses these findings, and Section 7 concludes.

Section 2: Literature Review and Theoretical Framework

2.1 The British Patenting System: The Mid-19th Century to Early 20th Century

Pre-1852

Before reform in 1852, Britain's patenting system was expensive and inefficient, hence only 14,359 patents were granted between 1624 and 1852.[6] An English patent cost £100, a skilled worker's annual wage, rising to £300 to extend its coverage to Scotland and Ireland.[7] Navigating up to 35 government offices added further expense, often requiring the employment of a patent agent.[8] Legal hostility also meant patents were frequently infringed upon; only 257 cases out of 11,962 patents went before the courts between 1770 and 1850.[9] These high costs, rooted in mistrust of monopolies, excluded capital-constrained inventors.[10] Most inventors of the industrial revolution therefore innovated outside the

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[6] Khan and Sokoloff 2008, "Historical Perspectives," Page 218
[7] MacLeod et al. 2003, "Evaluating Inventive Activity," Page 541
[8]MacLeod et al. 2003, "Evaluating Inventive Activity," Page 541; Khan and Sokoloff 2008, "Historical Perspectives," Page 219
[9] Joel Mokyr, "Intellectual Property Rights, the Industrial Revolution, and the Beginnings of Modern Economic Growth," *American Economic Review* 99, no. 2 (April 2009): 349–55, https://doi.org/10.1257/aer.99.2.349. Page 350
[10] MacLeod et al. 2003, "Evaluating Inventive Activity," Page 540

system through 'collective invention' processes.[11] The geography of invention was also highly uneven; London contributed 45% to aggregate patenting 1617-1852, with the second largest contributing city being Birmingham at 5%, and second largest county Lancashire at 12.7%.[12]

Despite calls for reform, legislative change was slow to materialise.[13] However the 1851 Crystal Palace World Fair changed this. Based on exhibition data from this fair, Moser (2005) finds that 89% of British inventions were not patented.[14] The exhibition revealed the system's backwardness compared to the US and Europe, emphasising the urgent need for reform.[15]

1852 Reform

The 1852 Patent Law Amendment Act marked a major turning point. It created a single British patent office, rationalised the application process, and reduced the fee to £25, with renewals at 7 and 14 years.[16] Applications surged immediately, as show in Figure 1, jumping from 455 in 1851 to 1384 in 1852.[17] Relatively high fees were maintained to prevent the patenting of low-value inventions, assuming inventors with novel, viable inventions would self-select into the system.[18] Figure 1 shows most applications were granted until 1883, implying pre-application sorting. Yet, these costs still excluded many credit-constrained inventors with valuable inventions.[19]

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[11] Robert C. Allen, "Collective Invention," *Journal of Economic Behavior & Organization* 4, no. 1 (March 1983): 1–24, https://doi.org/10.1016/0167-2681(83)90023-9. Page 21

[12] Van Dulken 1999, *British Patents*, Page 5; Khan and Sokoloff 2008, "Historical Perspectives," Page 221; MacLeod et al. 2003, "Evaluating Inventive Activity," Page 539

[13] Van Dulken 1999, *British Patents*, Page 85

[14] Petra Moser, "How Do Patent Laws Influence Innovation? Evidence from Nineteenth-Century World's Fairs," *American Economic Review* 95, no. 4 (August 2005): 1214–36, https://doi.org/10.1257/0002828054825501. Page 1220

[15] Khan and Sokoloff 2008, "Historical Perspectives," Page 222

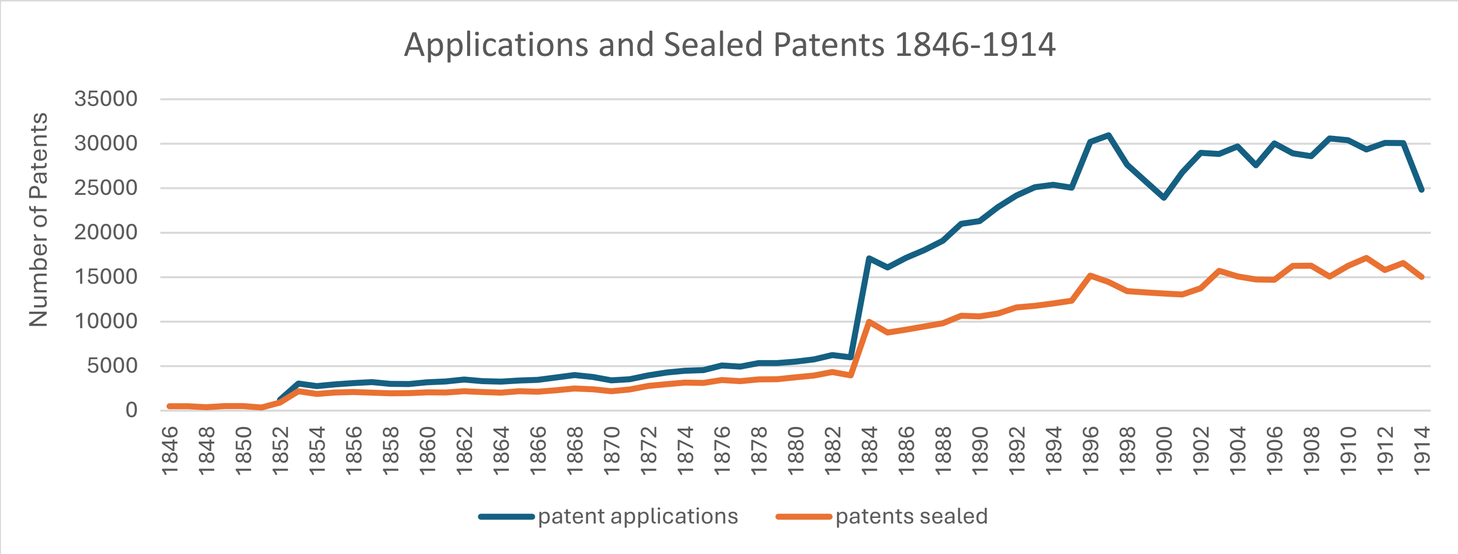
[16] Van Dulken 1999, *British Patents*, Pages 3, 25

[17] Zorina Khan and Kenneth Sokoloff, "Patent Institutions, Industrial Organisation and Early Technological Change: Britain and the United States, 1790-1850," in *Technological Revolutions in Europe* (Edward Elgar Publishing Limited, 1998). Page 99

[18] MacLeod et al. 2003, "Evaluating Inventive Activity," Page 542

[19] Stephen D Billington, Christopher L Colvin, and Christopher Coyle, "Financing Innovation: The Role of Patent Examination," *QUECH Working Paper Series* 25-01 (January 2025). Page 5

Figure 1: Patent Applications and Patents Sealed 1846-1912



Source: British Library, Board of Trade, Patents, Designs and Trade Marks Office, Comptrollers Reports, The Report of The Commissioners of Patents for Inventions 1852-1915

1883 Reform

Timed to coincide with the Paris Convention of Industrial Property, further reform in 1883 rationalised processes and reduced fees drastically to £4.[20] As illustrated in Figure 1, patentee activity was highly sensitive to this cost reduction. Applications trebled overnight, from 6,000 to over 17,000 in 1884.[21] Despite this aggregate increase, the 1904 Comptrollers report outlines unequal distribution across industries, with inventive activity in agriculture and shipbuilding, for example, remaining stagnant.[22]

The 1883 Act introduced only limited novelty examination, checking only for single inventions and accurate description.[23] Combined with the cost decrease, this meant applications were no longer primarily quality-selected, and no formal

[20] Van Dulken 1999, *British Patents*, Page 5; Khan and Sokoloff 2008, "Historical Perspectives," Page 221; MacLeod et al. 2003, "Evaluating Inventive Activity," Page 539
[21] Tom Nicholas, "Cheaper Patents," *Research Policy* 40, no. 2 (March 2011): 325–39, https://doi.org/10.1016/j.respol.2010.10.012. Page 326
[22] British Library, Board of Trade, Patents, Designs and Trade Marks Office, Comptrollers Reports, The Report of The Commissioners of Patents for Inventions 1904, page 11
[23] Van Dulken 1999, *British Patents*, Page 5; MacLeod et al. 2003, "Evaluating Inventive Activity," Page 541

mechanism assessed low-value patents.[24] Despite increasing divergence between applications and patents sealed post-1883 in Figure 1, many granted patents were of low social value.[25]

1902 Policy Change

Unsurprisingly, the 1901 Fry Committee found 42% of a patent sample partially or wholly anticipated by prior art, driving the 1902 Policy.[26] Effective from January 1, 1905, this Act introduced novelty examination for the first time in the British system.[27] Previously, patentees were responsible for ensuring novelty, leading to significant duplication. The Act addressed this by establishing novelty examiners in 32 technological specialisations to search inventions from the previous 50 years.[28] If a lack of novelty was found inventors could either revise their application or withdraw.[29] This search added £1 to the £4 fee.[30]

The 1906 Comptroller's report stated the Act was processed satisfactorily, with an immediate increase in complete specifications filed.[31] They attributed these increased rates to the official search's benefit to inventors.[32] The examination aimed to prevent low-value patents and duplication, estimated at 25-42% of late 19th-century patents, theoretically increasing granted patents' reliability and value.[33] While the £1 fee posed a barrier for some, increased quality and reduced infringement risk also potentially made the system more attractive for high-value inventions.[34]

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[24] Billington et al. 2025, "Financing Innovation," Page 6
[25] Billington et al. 2025, "Financing Innovation," Page 6
[26] Van Dulken 1999, *British Patents*, Page 28
[27] Khan and Sokoloff 2008, "Historical Perspectives," Page 221; Van Dulken 1999, *British Patents*, Page 5
[28]Van Dulken 1999, *British Patents*, Page 28; MacLeod et al. 2003, "Evaluating Inventive Activity," Page 541; Comptroller Reports 1909, page 4
[29] Billington et al. 2025, "Financing Innovation," Page 3
[30] Comptroller Reports, 1906, page 4
[31] Comptroller Reports 1906, Page 4
[32] Comptroller Reports 1906, Page 4
[33] MacLeod et al. 2003, "Evaluating Inventive Activity," Page 548
[34] Billington et al. 2025, "Financing Innovation," Page 5

Although patenting becomes more cyclical from 1900, Figure 1 shows a decrease in applications and patents sealed in 1905, which recovers by 1906. This increased patent quality was also echoed in the 1906 Comptrollers report where the number of applications voided due to being incomplete increased in 1905 to 1374, from an average of 196 per year, in the 10 years prior.[35] The 1909 Report further emphasised examination increasing patent quality and international comparability.[36] The regional impact of this policy will be the topic of investigation in this paper.

1907 Policy Change

The Patents and Designs Amendment Act 1907 consolidated this, effective from January 1, 1908.[37] It banned 'frivolous' patents and allowed refusal for lack of novelty.[38] No later major acts occurred until 1919 due to World War One.[39]

2.2 Literature Review

Late 19th and early 20th century British patent reforms have received limited academic attention, largely due to digitalised British patent datasets only recently becoming available. Research on the geography of invention before 1980 is thus primarily US-centric, leveraging data from 1836 from the US Patenting and Trademark Office (USPTO). For example, Andrews and Whalley (2021) use geographically linked patent data to study the changing geography of invention in the 1836-2016 period, and Moser (2011) analyses the effect of patenting on the diffusion of innovative activity from data on exhibiting US firms at world fairs 1851-1915.[40] This leaves significant gaps for British and European contexts.

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[35] Comptroller Reports 1906, page 5
[36] Comptroller Reports 1909, page 5
[37] Stephen Adams, "Centenary of the Enactment of the United Kingdom's Patents and Designs Act 1907," *World Patent Information* 29 (2007): 363–68. Page 364
[38] Van Dulken 1999, *British Patents*, Page 5; MacLeod et al. 2003, "Evaluating Inventive Activity," Page 541
[39] Van Dulken 1999, *British Patents*, Page 5
[40] Michael J. Andrews and Alexander Whalley, "150 Years of the Geography of Innovation," *Regional Science and Urban Economics* 94 (January 2021): 103627, https://doi.org/10.1016/j.regsciurbeco.2020.103627. Pages 1-3; Petra Moser, "Do Patents Weaken the Localization of Innovations? Evidence from World's Fairs," *The Journal of Economic History* 71, no. 2 (June 6, 2011): 363–82, https://doi.org/10.1017/s0022050711001562. Page 378

Research on British policies has focused on the filtering effects and subsequent implications for patent quality. Sullivan (1994) first analysed the private value of British patents 1852-76 using renewal data, resting on the assumption that renewal occurs when the expected profit exceeds renewal costs.[41] Sullivan finds an 80% increase in patent value across the period, with a 59% increase in those surviving 3 years.[42] He argues the high-fee system filtered out low-value patents, leaving only the 10% most valuable patents remaining after the 7th year.[43] However, assuming renewal decisions are based only off expected profits ignores market conditions and credit constraints. Hence subsequent research, critically evaluating this assumption has challenged this view. MacLeod et al. (2003) argue the high costs were not an effective alternative for official novelty examination.[44] Examining the steam-engineering industry 1852-1914, MacLeod et al. further analyse patent renewal data from Patent Office abridgement specifications, finding 95% of applications being of low-social value.[45] They conclude that the system was not effective, and prevented the patenting of high-social value inventions from credit-constrained inventors.[46] While this is valuable as a case study, this may not however be reflective of all industries.

Building upon this, Nicholas (2011) examines the impacts of the 84% fee reduction from the 1883 reform.[47] Using a 20% random sample of British patents 5 years before and after the policy, and renewal data to measure quality, Nicholas employs a difference-in-difference approach with British inventors in the US inventors as a control.[48] He finds no significant change in the geographical, quality or sectoral distribution of patenting as a result of the policy.[49] Despite interesting conclusions, critiques remain regarding the small 20% sample used and, more broadly, the fundamental flaw of using renewal data

[41] Richard J. Sullivan, "Estimates of the Value of Patent Rights in Great Britain and Ireland, 1852- 1876," *Economica* 61, no. 241 (February 1994): 37, https://doi.org/10.2307/2555048. Page 39
[42] Sullivan 1994, "Estimates of the Value," Page 49
[43] Sullivan 1994, "Estimates of the Value," Page 49
[44] MacLeod et al. 2003, "Evaluating Inventive Activity," Page 560
[45] MacLeod et al. 2003, "Evaluating Inventive Activity," Pages 549, 548
[46] MacLeod et al. 2003, "Evaluating Inventive Activity," Pages 559, 560
[47] Nicholas 2011, "Cheaper Patents," Page 325
[48] Nicholas 2011, "Cheaper Patents," Page 325
[49] Nicholas 2011, "Cheaper Patents," Pages 326, 332, 135

alone to measure quality, which can skew results due to credit constraints or wealthy patentees.

Less research addresses the impact of patent protection and examination directly on innovation. More broadly, Lerner (2009) finds a negative impact of patent protection on innovation when analysing 177 of the most significant patent policy shifts across 60 countries 1850-200.[50] Though the 2-year post-policy analysis period may be insufficient given patents took months to be sealed in earlier periods. More recently, de Rassenfosse et al. (2021) found patent quality to be higher in systems with rigorous examination, examining 400,000 inventions across multiple offices.[51] Therefore, analysing the first shift towards patent examination in Britain, aimed at enhancing patent quality, gives valuable insights into the potential disparities in invention quality across regions.

Crucially, despite these studies, there has been extremely limited research specifically on the 1902 policy introducing examination. Recently, Billington et al. (2025) analyse whether the introduction of examination in 1905 affected patenting firms access to finance.[52] Using PATSTAT data 6 years before and after 1905, and data from all patenting firms listed on the London Stock Exchange, they employ a difference-in-difference approach, using non-patenting firms as a control.[53] They find overall increased patent quality, signalled by increased abandonment, and increased credit access and growth of innovative firms due to reductions in information asymmetries between inventors and investors about invention quality.[54] While revealing important aggregate effect, this research raises questions about the distributional effects of the policy.

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[50] Josh Lerner, "The Empirical Impact of Intellectual Property Rights on Innovation: Puzzles and Clues," *American Economic Review* 99, no. 2 (April 2009): 343–48, https://doi.org/10.1257/aer.99.2.343. Page 347

[51] Gaétan de Rassenfosse et al., "Low-Quality Patents in the Eye of the Beholder: Evidence from Multiple Examiners," *The Journal of Law, Economics, and Organization* 37, no. 3 (May 1, 2021), https://doi.org/10.3386/w22244. Page 627, 628

[52] Billington et al. 2025, "Financing Innovation," Page 3

[53] Billington et al. 2025, "Financing Innovation," Page 3

[54] Billington et al. 2025, "Financing Innovation," Pages 3, 12

Therefore, while existing research provides valuable insights into the motivation and aggregate consequences of the novelty examination, a gap remains in the spatial impact of this policy. Understanding the interaction between this policy and the uneven geography of invention discussed below warrants exploration.

2.3 The Uneven Geography of Inventive Activity

The geographic distribution of inventive activity is crucial for understanding regional economic growth and inequalities. Innovation drives growth, as posited by Romer's Endogenous Growth Theory, where technological change is endogenous to market incentives.[55] In the model, technological change occurs due to intentional actions taken by people who react to market incentives, hence making technological change endogenous to growth.[56] Neoclassical theory highlights the role of patents in incentivising inventors via royalties and social benefits.[57] Therefore, analysing regional patterns of invention, especially post-Industrial Revolution, is essential given the tendency towards persistence and path-dependency in innovative regions.

Regional inequality in Britain was prevalent during this period, with significant disparities in GDP shares.[58] London consistently held around 19.6% of national GDP 1861-1911, the North West 13%, while East Anglia held only 2.4%.[59] Due to incomplete data, the direction of regional inequality is debated; Martin (1988) and Crafts (2005) argue for increasing inequality driven by the lagging North.[60] Whereas, Geary and Stark (2016) argue for decreasing inequality 1860-1914,

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[55] Paul M Romer, "Endogenous Technological Change," *The Journal of Political Economy* 98, no. 5 (1990), http://links.jstor.org/sici?sici=0022-3808%28199010%2998%3A5%3CS71%3AETC%3E2.0.CO%3B2-8. Page 72

[56] Romer 1990, "Endogenous Technological Change," Page 72

[57] Sean Bottomley, *The British Patent System during the Industrial Revolution, 1700-1852: From Privilege to Property* (Cambridge, United Kingdom: Cambridge University Press, 2014). Page 10

[58] Frank Geary and Tom Stark, "Regional GDP in the UK, 1861–1911: New Estimates," *Economic History Review* 68, no. 1 (2015), https://doi.org/123%E2%80%93144. Page 129

[59] Geary and Stark 2015, "Regional GDP 1861–1911," Page 129

[60] Ron Martin, "The Political Economy of Britain's North-South Divide," *Transactions of the Institute of British Geographers* 13, no. 4 (1988): 389–418. Page 389; Nicholas Crafts, "Regional GDP in Britain, 1871-1911: Some Estimates," *Scottish Journal of Political Economy* 52, no. 1 (February 24, 2005), https://onlinelibrary.wiley.com/doi/full/10.1111/j.0036-9292.2005.00334.x. page 58

driven by the catching-up of Northern regions.[61] However regardless of direction, persistent regional disparities provides critical context for examining the spatial effects of innovation policies.

The uneven geography and clustering of economic and inventive activity can be explained through agglomeration theories. Marshall (1890) attributes agglomerations within the same industries to benefits from input sharing, labour pooling and knowledge spillovers.[62] Knowledge spillovers are particularly important, fostering clusters of innovative firms which benefit from regionally embedded tacit knowledge transfers, leading to an unequal distribution of inventive activity.[63] During the industrial revolution, these forces led to regional specialisations, such as shipbuilding in Glasgow, steel in Sheffield and wool in Yorkshire. Exemplifying Lancashire's cotton industry, Marshall himself discusses how this geographic specialisation leads to superior returns from industrial size and efficiency.[64] Surrounding towns specialised in the production of specific goods, for example Blackburn in Indian fabrics, Rochdale with shirts and Burnley with Printed cloths.[65] Gragnolati and Nuvolari (2023) find the location of inventors to be closely intertwined with the spatial distribution of productive activities during the Industrial Revolution, with localised interactions between inventors leading to increasingly concentrated innovative activities.[66]

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[61] Frank Geary and Tom Stark, "What Happened to Regional Inequality in Britain in the Twentieth Century?," *The Economic History Review* 69, no. 1 (2016): 215–28, https://doi.org/10.1111/ehr.12114. Page 215

[62] Alfred Marshall, *The Agents of Production, Land, Labour, Capital and Organization, the Principles of Economics* (Macmillan and Co., 1890). Pages 267-277

[63] Maryann P. Feldman and Dieter F. Kogler, "Stylized Facts in the Geography of Innovation," in *Handbook of the Economics of Innovation*, 2010, 381–410, https://doi.org/10.1016/S0169-7218(10)01008-7. Page 387

[64] Alfred Marshall, *Industry and Trade* (Macmillan, 1919), https://archive.org/details/industrytradestu0000alfr/page/n9/mode/2up. Page 602

[65] Peter Sunley, "Marshallian Industrial Districts: The Case of the Lancashire Cotton Industry in the Inter-War Years," *Transactions of the Institute of British Geographers* 17, no. 3 (1992): https://doi.org/10.2307/622882. Page 310

[66] Ugo M. Gragnolati and Alessandro Nuvolari, "Innovation, Localized Externalities, and the British Industrial Revolution, 1700-1850," *LEM Working Paper Series* 2023-26 (2023). Pages 28,29

Conversely, Jacobs (1969) argues that city diversity is a major agglomerative force, enhancing cross-fertilisation of ideas between industries.[67] Physical proximity offered by cities lowers the cost of encountering new ideas, increasing innovation.[68] Cities became increasingly important in this period; in 1800 only London had over 100,000 inhabitants, but this rose to 23 cities by 1901 and 38 by World War One.[69] These large cities became hubs for diverse industries and agglomerations, giving rise to regions such as the West Midlands and Yorkshire.[70]

Empirical research confirms cities to be a site of intensive knowledge production. Analysing US patents 1836-2010 Packalen and Bhattacharya (2015) found larger US cities offered a considerable advantage in inventive activities during the 19th and 20th centuries.[71] For Britain, using a panel of 31 English cities 1851-1911, Hanlon and Miscio (2017) found the strongest agglomeration effects stemmed from cross-industry spillovers, supporting Jacobs, while within-industry effects were negative.[72] They found high agglomeration levels in British manufacturing comparable to modern US levels, leading to extremely uneven distributions of growth and persistent inequalities.[73]

In summary, literature on the geography of invention highlights persistent unevenness shaped by agglomeration forces, urbanisation, and industry specialisation. These established regional dynamics provide crucial geographical context for understanding how a national policy change, like the 1905

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[67]Jane Jacobs, "How New Work Begins," in *The Economy of Cities* (Knopf Doubleday Publishing Group, 1969). Pages 50-55

[68] Mikko Packalen and Jay Bhattacharya, "Cities and Ideas," *NBER Working Paper Series, National Bureau of Economic Research*, 2015, https://www.nber.org/papers/w20921. Page 1

[69] Peter Scott, "British Regional Development before the Twentieth Century," in *Triumph of the South* (Triumph of the South, 2007), https://www.taylorfrancis.com/books/mono/10.4324/9781351144049/triumph-south-peter-scott. Page 13

[70] Scott 2007, *Triumph of the South*, Page 13

[71]Packalen and Bhattacharya 2015, "Cities and Ideas," Pages 7,14

[72] W Walker Hanlon and Antonio Miscio, "Agglomeration: A Long-Run Panel Data Approach," *Journal of Urban Economics* 99 (January 17, 2017): 1–14, https://doi.org/10.1016/j.jue.2017.01.001. Pages 2,3,13

[73] Hanlon and Miscio 2017, "Agglomeration," Page 6

introduction of patent novelty examination, might have had differential effects across Britain.

2.4 Theoretical Discussion

Building on the historical context and literature review, this section outlines theoretical mechanisms through which the 1905 introduction of novelty examination could have differentially impacted regional patenting distribution in Britain.

One primary mechanism is the policy's effect on cost. The additional £1 fee, worth over £100 today, increased the financial barrier.[74] Given the cost-sensitivity of patentees, and potential regional disparities in income and access to capital, this may disproportionately deter inventors in lower-affluence regions, theoretically shifting patenting towards wealthier or financially robust areas.

A second mechanism involves the novelty examination, increasing red-tape and acting as a quality filter. By identifying duplicate inventions, it aimed to deter low-quality patenting. This filtering would disproportionately reduce recorded activity in regions where such low-quality or imitative invention was more prevalent. Equally, for inventors with novel ideas, examination offered increased confidence in the protection and enforcement of sealed (granted) patents. This mechanism could facilitate investment and commercialisation by reducing information asymmetries, as highlighted by Billington et al. (2025).

These distinct policy mechanisms may interact with the uneven geography of inventive activity discussed in Section 2.3, leading to differential impacts across regions. Regions dominated by industries that innovate though collective invention may see a stronger deterrent effect, leading to decreases in patenting activity. Conversely, regions with strong innovation ecosystems, research institutions, sophisticated industries or better capital access might see a relatively larger increase in high-quality patenting. Equally, regions specialising

[74] Bank of England 2025, "Inflation Calculator."

in rapidly evolving or research-intensive sectors might benefit more from the clarity and protection offered by the novelty examination compared to regions dominated by more mature or less patent-intensive industries.

The theoretical increase in patent quality, as empirically found by Billington et al. (2025), also suggests that any observed changes in patenting activity could reflect a shift towards a new distribution of higher-quality patents, more accurately representing previously inflated activity.[75]

Ultimately, the net regional impact of these countervailing forces is the empirical question asked by this research. While this paper does not test for effects on regional economic growth, implications of changes in inventive activity distribution would be significant for growth and inequality.

Section 3: Source Discussion

3.1 Patent Data

To assess the regional impact of the 1902 policy, I obtain patent data from the PatentCity dataset by Bergeaud and Verluise (2022).[76] This novel dataset was created for research on the geography of innovation, containing geocoded information on every patent sealed from the US, German, French and UK intellectual property offices.[77]

Each entry includes the publication date, inventor information such as occupation, and address.[78] This data was extracted from original patent documents using automated text extraction software, which is accurate at the 0.92 precision rate.[79] For addresses, this was then further geocoded, which is

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[75] Billington et al. 2025, "Financing Innovation"
[76] Antonin Bergeaud and Cyril Verluise, "A New Dataset to Study a Century of Innovation in Europe and in the US," *Research Policy* 53, no. 1 (November 4, 2022): 104903–3, https://doi.org/10.1016/j.respol.2023.104903.
[77] Bergeaud and Verluise 2022, "New Dataset," Page 1
[78] Bergeaud and Verluise 2022, "New Dataset," Page 1
[79] Bergeaud and Verluise 2022, "New Dataset," Page 5

extremely reliable in the UK, with a match rate of 0.924 at the state level, and 0.91 at the county level.[80] Whilst there is little concern about data accuracy, some entries aren't geocoded. Based on rough estimations in Appendix 1.1, the dataset used for this analysis covers around 70% of total patents in these years. Assuming those not geocoded are randomly distributed, this should not significantly bias the analysis.

I extracted every British patent 1895-1915 from domestic inventors with geocoded entries, 10 years before and after 1905, totalling over 115,000 patents. Addresses were often incomplete, so I manually reviewed entries and sorted them into the correct region. I also extracted patentee occupations for 1904, 1906 and 1910, approximately 9,000 patents. Due to inaccuracies requiring manual correction, focussing on only three years was feasible. While lower coverage, this offers insights into regional patentee characteristics. I manually sorted occupations into the occupational classes used in the census.[81] A breakdown of occupation data is provided in Appendix 1.2

There are issues with using patent data. Firstly, patent statistics don't differentiate radical or minor inventions, or between those with any commercial value.[82] Citation analysis is an alternative but outside of this study's scope. Furthermore, patents measure only 'formal' inventive activity, as some inventions aren't patentable, such as biological and organisational changes in farming.[83] Sullivan (1989) argues that due to this, patent data doesn't accurately reflect inventive activity over long periods of time, however due to the relatively short period of my analysis this shouldn't be a significant issue.[84]

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[80] Bergeaud and Verluise 2022, "New Dataset," Page 5
[81] C.H. Lee, *British Regional Employment Statistics 1841-1971* (Cambridge University Press, 1979). Pages 18-24
[82] Joel Moykr, "The Lever of Riches: Technological Creativity and Economic Progress," *Choice Reviews Online* 28, no. 02 (October 1, 1990): 28–105628–1056, https://doi.org/10.5860/choice.28-1056 page 82 ; Van Dulken 1999, *British Patents*, Page 171
[83] Richard J Sullivan, "England's 'Age of Invention': The Acceleration of Patents and Patentable Invention during the Industrial Revolution," *Explorations in Economic History* 26, no. 4 (October 1989): 424–52, https://doi.org/10.1016/0014-4983(89)90017-x. page 431
[84] Sullivan 1989, "Age of Invention," Page 426

The most notable concern for regional analysis is varying industry propensities to patent, and the concentration of these industries in certain regions.[85] For example, low patenting in a region could be due to invention in their dominant industry occurring through collective invention outside the patenting system.[86] Using a 1993 survey on the innovative activities of Europe's largest industrial firms, Arundel and Kabla (1998) find the patent propensity for product innovations vary significantly by industry, for example, at 8.1% in textiles and 79.2% in pharmaceuticals.[87] Further complicating this, the PatentCity dataset does not provide industrial class, therefore to overcome this issue I use regional employment statistics, as discussed below.

Despite concerns, patents are a good indicator of overall inventive activity. There is evidence from studies such as Pakes and Griliches (1980) and Acs and Audretsch (1989), that patents, although not without fault, are a fairly reliable measure of inventive and innovative activity.[88] Schmookler (1962) further argues that many of the most damaging criticisms of patent data are less significant when analysing the 19th and early 20th century, given that independent inventors were the major source of inventions, and they therefore had to patent their inventions to make profit.[89]

3.2 Regional Employment Statistics

To control for industries, I use regional employment statistics created by Lee (1979), which draw directly from the censuses of England and Scotland.[90] This acts both as a control for differing propensities to patent between industries and

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[85] Moykr 1990, "Lever of Riches," Page 82
[86] Sullivan 1989, "Age of Invention," Page 431
[87] Anthony Arundel and Isabelle Kabla, "What Percentage of Innovations Are Patented? Empirical Estimates for European Firms," *Research Policy* 27, no. 2 (June 1998): 127–41, https://doi.org/10.1016/s0048-7333(98)00033-x. page 127
[88] Ariel Pakes and Zvi Griliches, "Patents and R&D at the Firm Level: A First Report," *Economics Letters* 5, no. 4 (January 1980): 377–81, https://doi.org/10.1016/0165-1765(80)90136-6. Page 181; Zoltan J. Acs and David B. Audretsch, "Patents as a Measure of Innovative Activity," *Kyklos* 42, no. 2 (August 1989): 171–80, https://doi.org/10.1111/j.1467-6435.1989.tb00186.x. page 177
[89] Jacob Schmookler, "Economic Sources of Inventive Activity," *The Journal of Economic History* 22, no. 1 (March 1962): 1–20, https://doi.org/10.1017/s0022050700102311.page 3
[90] Lee 1979, *British Regional* Employment Statistics

also captures any changes in patenting that result from general economic activity within a region. I use employment data from 28 industries, between 1891-1911, across 11 regions including Scotland and Wales.

The census methodology underwent significant change in 1901, resulting in major discontinuities between Series A (1841-1911) and Series B (1901-1971).[91] Despite an 89% overlap in 1911, the differences were too complex to merge the two series.[92] For simplicity, I use only series A given my data falls predominantly within this range, and linearly interpolate data for other years.

There are some complications with census data. For example, regarding occupational classification, if a person stated they worked as a cotton merchant, they were classified under cotton, but if they just said merchant, they were recorded under 'not classified'.[93] Not classified also covers general merchants, commercial clerks, commercial travellers due to impossibility of allocating them industrial groups.[94] This complicates industry-level analysis. Furthermore, nuances between classifications require explanation. For example, metal manufacture covers occupations in 'metal manufacture' and the working of metals, whereas 'metal goods not specified' is the manufacture of specific metals goods such as cutlery, nuts and bolts.[95] To see the full breakdown of occupations in each industrial class, see Lee (1979), pages 18-24.[96]

Further complications exist from the 1891 change from registration counties to 1901 administrative counties.[97] This would cause significant issues if my analysis was at the county level, however at the regional level this isn't a large issue. The common core, the proportion of population unaffected by the changes, for each region captured in the 1901 census that records both boundaries is

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[91] Lee 1979, *British Regional* Employment Statistics, page 5
[92] Lee 1979, *British Regional* Employment Statistics, page 5
[93] Lee 1979, *British Regional* Employment Statistics, page 16
[94] Lee 1979, *British Regional* Employment Statistics, page 16
[95] Lee 1979, *British Regional* Employment Statistics, page 14
[96] Lee 1979, *British Regional* Employment Statistics, Pages 18-24
[97] Lee 1979, *British Regional* Employment Statistics, page 39

extremely high.[98] For example for the Southeast it is 99.6, and the lowest is the East Midlands at 95.7, implying that at the regional level this should not affect results.[99]

3.3 Other Sources

To supplement analysis, I use reports from the Commissioners of Patents 1852-1915.[100] These provide background and overall trends. While lacking regional data, later reports discuss the status of policies and industry trends, valuable for contextualising results.[101]

For data presentation, I use shapefiles of British regions based on NUTS 2018 boundaries.[102] These differ slightly from historical boundaries, but are for visualisation only, not geospatial analysis.

Section 4: Methodology

To empirically assess the regional impact of the 1902 novelty examination policy, theorised in Section 2.4, I employ panel regression analysis using the data sources described in Section 3. The analysis focuses on the quantity of patents sealed by domestic inventors across 11 standard British regions over the 1897-1913 period. This timeframe, encompassing eight years before and after the 1905 policy, allows balanced comparison while avoiding the effects of World War One. London is separated from the Southeast due to its distinct structure and dominance, as explained in Appendix 2.1.

I construct a panel dataset across these 11 regions and 17 years, 1897-1913. To account for time-varying regional characteristics, industry composition, and

[98] Lee 1979, *British Regional* Employment Statistics, page 44
[99] Lee 1979, *British Regional* Employment Statistics, page 44
[100] Comptroller Reports 1852-1915
[101] Comptroller Reports 1852-1915; Van Dulken 1999, *British Patents*, Page 4
[102] ONS Geography, "NUTS, Level 1 (January 2018) Boundaries UK BSC," Office for National Statistics, accessed March 25, 2025, https://geoportal.statistics.gov.uk/datasets/ons::nuts-level-1-january-2018-boundaries-uk-bsc/about.

differing propensities to patent, I include regional employment data from 28 industries from Lee (1979) as controls. Employment data, linearly interpolated between census years (1891, 1901 and 1911), controls for industry-specific economic trends and patenting propensities across regions and time. All models also include year fixed effects to control for unobserved national shocks or trends affecting all regions simultaneously.

Before the primary approach, focusing on within-region effects with region-specific controls, I estimate two baseline panel regression models with year fixed effects.

Equation 1: Baseline Model - Regional Interactions Without Industry Controls
This baseline model examines whether the post-policy change in patenting differed across regions.

$$\text{ln\_Patents\_Seale}d_{rt} = \text{ß}0 + \text{ß}1\cdot\text{Post\_Polic}y_t + \text{ß}2\cdot(\text{Post\_polic}y_t xRegion_r) + \alpha_r + \gamma_t + \epsilon_{rt}$$

In Equation 1, ln_Patents_Sealedrt is the natural log of patents sealed in region r in year t. The log transformation normalises the distribution. Post_Policyt is the dummy independent variable, equalling 1 if after the reform or 0 if before, capturing the effect of the policy. ß1 estimates this effect for a standard region. Post_Policy$t$xRegion$r$ is the interaction; ß2 measures how the policy effect varies across regions compared to the base region. αr represents regional fixed effects, controlling for time-invariant differences across regions. γt represents the year fixed effects, controlling for common national shocks affecting all regions in a given year. ϵrt is the error term, which captures the variation in patenting activity not explained by the model for region r in year t. This model excludes industry controls.

Equation 2: Baseline Model - Industry Controls Without Regional Interactions

This second baseline model examines the relationship between patenting activity and industries, pooling all regions together and without including regional interactions or separate regional fixed effects.

$$\text{ln\_Patents\_Sealed}_{rt} = \beta 0 + \beta 1 \cdot \text{Post\_Policy}_t + \text{Industry\_Employments} + \gamma_t + \epsilon_{rt}$$

As in Equation 1, ln_Patents_Sealedrt is the natural log patent count and Post_Policyt is the policy dummy. β1 estimates the aggregate national change post-policy, accounting for industry types and year trends. Industry_Employments represents the 28 separate industry controls of the natural log of employment in each industry. It accounts for industry specific economic trends that may influence patenting activity and differing industry patenting propensities. γt represents the year fixed effects and ϵrt is the error term, as in Equation 1. Industry controls could not be interacted due to multicollinearity, which is discussed further in Appendix 2.2.

Equation 3: Individual Regional Regressions with Industry Controls

To analyse policy impacts within each region, I run separate regressions for each region, r. The equation for each region is:

$$\text{ln\_Patents\_Sealed}_{rt} = \beta 0 + \beta 1 \cdot \text{Post\_Policy}_t + \text{Region\_Industry\_Control\_Groups}_{rt} + \gamma_t + \epsilon_{rt}$$

Ln_Patents_Sealed rt is the log of the patent count for region r in year t. Post_Policyt is the policy dummy; β1 estimates the change in log patenting activity within region r post-1905, conditional on the region's employment composition and year trends. The variable Regional_Industry_Control_Groups represents the controls for aggregated industry employment groups specific to region r. γt represents the year fixed effects and ϵrt is the error term.

Due to multicollinearity when including all individual industry controls, I aggregated employment controls into region-specific groups based on correlation matrices of industrial employment. This means industry control groups differ by region and I cannot differentiate individual industry effects within regions. This is discussed further in Appendix 2.3.

Endogeneity Concerns

Firstly, employment data alone may not fully capture regional economic conditions. Other confounding variables omitted from the regression could influence patenting, such as financial and human capital, the presence of universities and regional-level shocks not impacting employment. Regional and year fixed effects control time-invariant regional differences and national trends, but time-varying regional variables may be omitted. Findings should thus be interpreted as associations concurrent with the policy, rather than definitive causal effects.

Furthermore, census employment classifications can complicate links to patenting. For example, the 'Professional and Scientific Services' category includes both high-patenting roles such as engineers and architects, and others less associated such as teachers and journalists.[103] An increase in this control might artificially explain a patenting increase potentially due to an unrelated shock increasing, for example, the number of teachers.

Reverse causality is also a concern if the policy impacted industry employment. While this is unlikely for an entire industry, it should be considered. Proving any effect of the policy on this would not be possible at this level, given the census occurs only every 10 years.

However, despite concerns, the employment in 28 different industries within every region provides comprehensive controls suitable for this level of analysis. Conveniently, due to regional policy only being implemented in Britain from the 1920's, policies that would influence both patenting and employment levels differentially between regions should not be a significant issue.

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[103] Lee 1979, *British Regional* Employment Statistics, page 23

Robustness Checks

Due to the later 1907 policy, I repeat this methodology setting the post-policy period to after 1908. For robustness checks, the pre/post window is reduced to 5 years to avoid the effects of World War One. The main analysis is repeated with this period and the same industry control groups are used for Equation 3.

Section 5: Results

5.1 Patenting and Economic Growth

Section 2.3 discussed the importance of invention for economic growth. The relationship between patenting activity and regional GDP in the sample underscores the importance of understanding policies that may alter the patterns of inventive activity. There is a very strong positive correlation between the quantity of patents and the share of national GDP across regions within the sample. A Pearson's correlation test confirms this; patent quantity and GDP per capita in 1901 have values of 0.9274 and 0.8572 with p-values of 0 and 0.0007 respectively. Figures 2a and 2b visually illustrate this strong positive correlation, showing the distribution of patenting share against GDP share for each region in 1901 and 1911.

Figure 2a: The Correlation Between Patenting share and share of GDP by Region (1901)

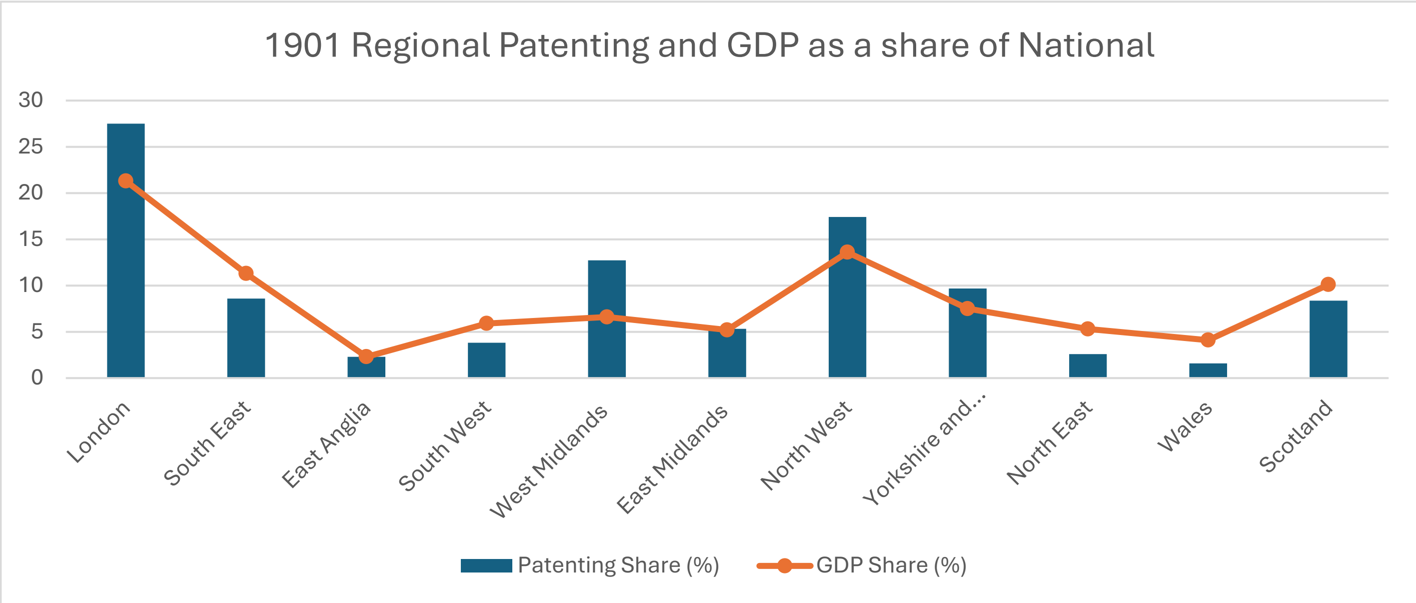
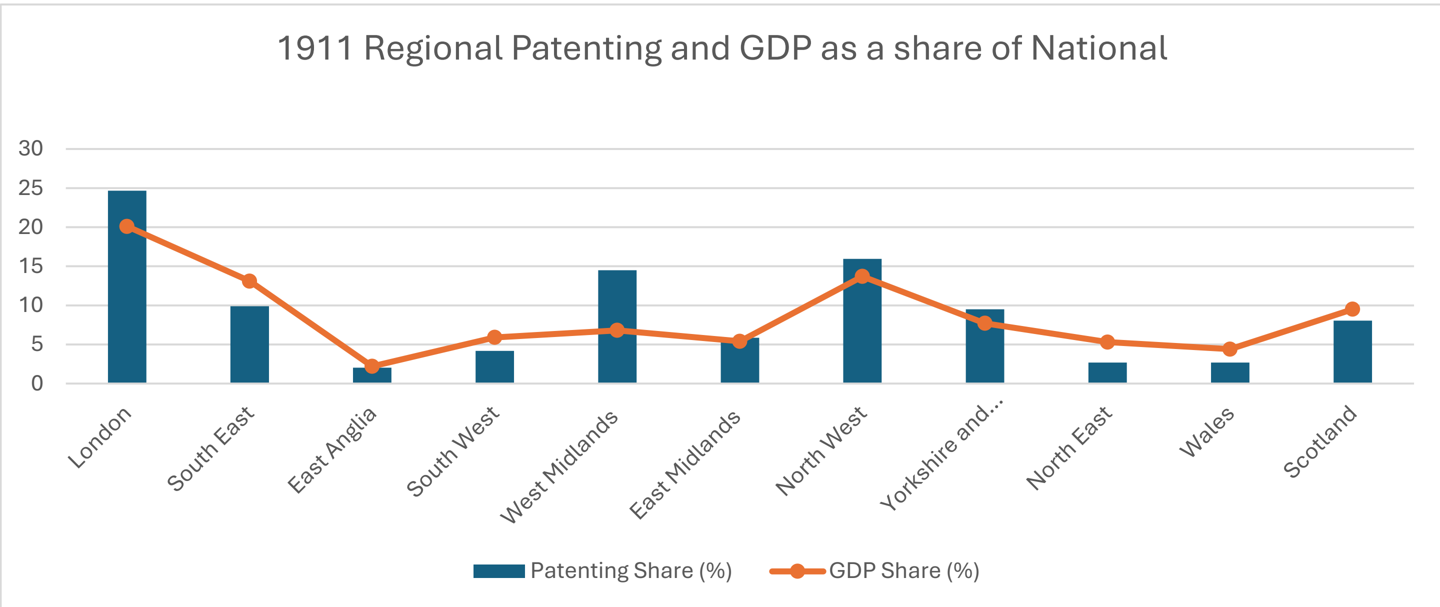


Figure 2b: The Correlation Between Patenting share and share of GDP by Region (1911)



Source: Frank Geary and Tom Stark, "Regional GDP in the UK, 1861–1911:New Estimates," Economic History Review 68, no. 1 (2015), https://doi.org/123%E2%80%93144, Page 129; Bergeaud, Antonin and Verluise Cyril. "PatentCity: A Dataset to Study the Location of Patents since the 19th Century." Harvard Dataverse, 2022. https://doi.org/doi:10.7910/DVN/PG6THV.

Figure 2a illustrates clear patterns across regions in the relationship between patenting and GDP shares. London, the West Midlands and the North West all have the highest shares of patenting activity, with shares higher than of GDP. In London this is likely attributable to Jacobian externalities. During this period, London had large industrial bases in multiple industries, employing 15% of all people working in Scientific and Professional Services, 28% of those in Publishing, as well as over 250,000 employed in both Transport and Communications, and Clothing and Footwear.[104] Its diverse economic base and concentration of multiple key industries explains why it hosts over 20% of GDP and 25% of total British patenting activity.[105] The North West provides a clear example of Marshallian Agglomeration, hosting 44% of all Textiles workers and 25% of those working in Mechanical Engineering, likely explaining the high GDP share and patenting rates.[106]

The West Midlands had a strong foundation in Metal Manufacturing, Electrical Engineering, and Other Metal Industries, which likely accounts for the high levels of patenting activity.[107] In 1901, electrical patents alone comprised 8% of all patents.[108] However, the West Midlands also employed 43% of all people working in 'Miscellaneous Services,' which mostly included various low-skilled domestic servants. This could explain why its share of GDP is lower.[109]

Wales and the Northeast both have GDP shares significantly higher than their share of patenting activity, as shown in Figure 2a. This is likely due to the regional dominance of mining as a key industry, which is high value but has a low propensity for invention. In 1901, mining employed nearly 25% of the Welsh population and 16% of the North East's population.[110] However, in 1901, there were only 82 mining patents filed out of over 14,000 total specifications.[111] East

[104] Lee 1979, *British Regional* Employment Statistics, pages 186-192, 210-216, 234-252
[105] Lee 1979, *British Regional* Employment Statistics, pages 186-192, 210-216, 234-252
[106] Lee 1979, *British Regional* Employment Statistics, pages 186-192, 210-216, 234-252
[107] Lee 1979, *British Regional* Employment Statistics, pages 186-192, 210-216, 234-252
[108]Comptroller Reports 1905, pages 15, 16
[109] Lee 1979, *British Regional* Employment Statistics, pages 186-192, 210-216, 234-252
[110] Lee 1979, *British Regional* Employment Statistics, pages 186-192, 210-216, 234-252
[111]Comptroller Reports 1905, pages 15, 16

Anglia has low shares of both patenting activity and GDP, likely due to agricultural employment dominating the region, with 27% of the working population employed in agriculture.[112] This sector is both lower in value and has a lower patenting rates. In 1901, only 273 patenting specifications were in agriculture.[113]

Figure 2b shows that these overall patterns persist to 1911, however some minor changes occur. For example, the Southwest experience an increase in share of aggregate patenting from 3.82% in 1901 to 4.17% in 1911, with their share of GDP remaining constant. London and the Northwest also experience a decline in the ratio of patent to GDP shares. In both cases this is driven by a decline in patenting shares rather than an increase in GDP shares. This shifting ratio could be due to artificially inflated inventive activity before the introduction of novelty examination in 1905, changes in regional industrial composition or purely cyclical fluctuations.

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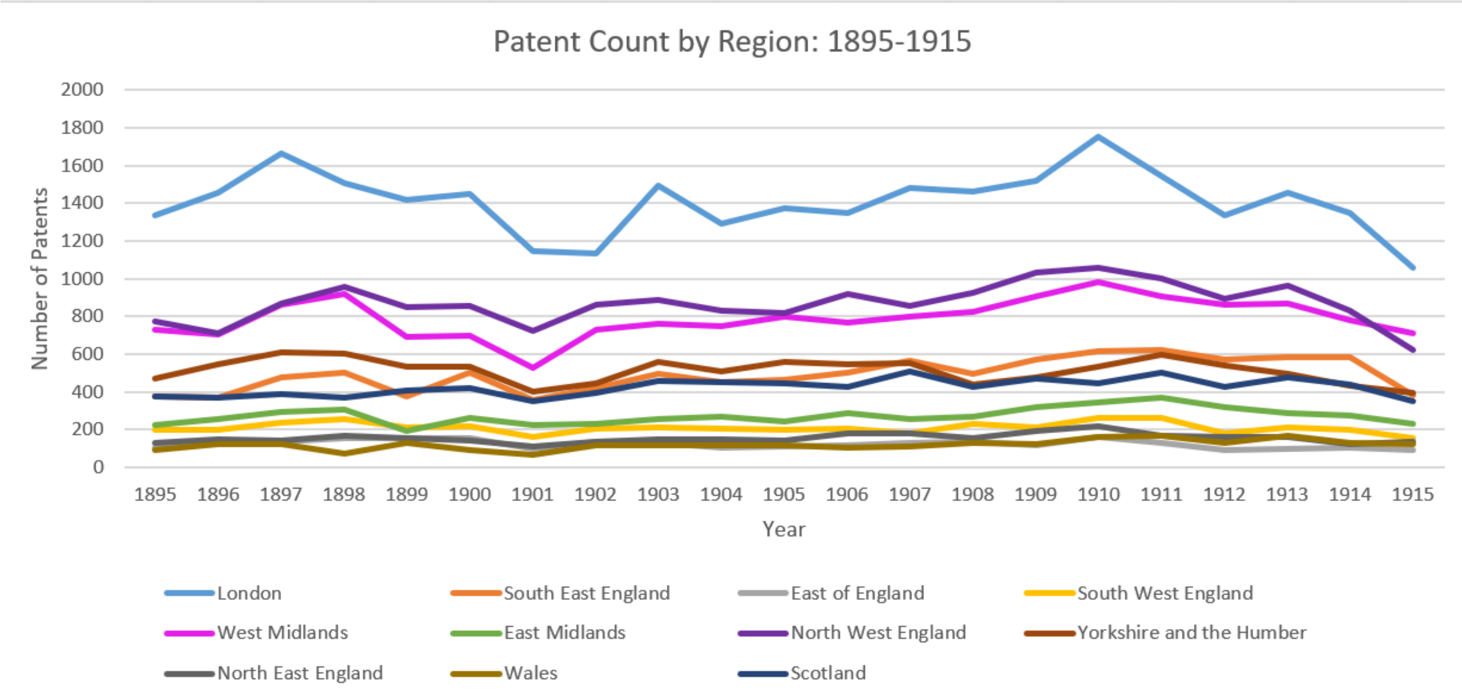
[112] Lee 1979, *British Regional* Employment Statistics, pages 186-192, 210-216, 234-252
[113]Comptroller Reports 1905, pages 15, 16

5.2 Spatial Overview and Analysis

Figure 3: Quantity of Patents Sealed across Regions, 1895-1915



Source: Bergeaud, Antonin and Verluise Cyril. "PatentCity: A Dataset to Study the Location of Patents since the 19th Century." Harvard Dataverse, 2022. https://doi.org/doi:10.7910/DVN/PG6THV

As illustrated in Figure 3, London consistently dominates patenting activity throughout the period. The West Midlands and the Northwest both show an upward trend in patenting starting around 1901. Each region experiences noticeable cyclical fluctuations. In 1905, Figure 3 reveals minor increases in patenting in London and the West Midlands, followed by a decrease in 1906. Similarly, the Northwest sees a slight decline in patenting activity in 1905, which then rises again by 1906. Figure 3 Also highlights the rapid decline in patenting from 1914 due to the incidence of World War One, hence my main analysis only covers the period up to 1913.

As illustrated in Figure 4, national patent shares echo these distinct regional patterns. London maintained its dominance throughout the period, with its share of patents increased by 1910. The actual number of London patents did increase by 6.4% between 1904 and 1905 in line with its increasing share.[114] Similarly, the West Midlands experienced this increase in shares 1904-1905, led by an increase in actual patenting rates of 6.5%.[115] The Southeast also experienced an increase in shares 1904-1905 and the Southwest's shares remained fairly constant, with both regions experiencing an increase in actual patenting rates in the period.

In contrast, the East Midlands faced a significant decrease in shares 1904-1905, recovering by 1906, despite a 9.7% decrease in actual patenting in this period.[116] The Northwest's shares saw a similar decline in 1905 and recovery by 1906, alhough their actual quantitiy of patenting increased. Yorkshire and Humberside faced similar patterns, where Figure 4 shows a 0.9% decline in shares 1904-1905, but this was accompanied by a 9.6% increase in their actual patenting rates.[117] Wales also experienced this decline in shares but in 1906, accompanied by an overall increase in activity. Scotland consistently declined in both shares with no increase in actual patenting rates.

[114] Lee 1979, *British Regional* Employment Statistics, pages 186-192, 210-216, 234-252
[115] Lee 1979, *British Regional* Employment Statistics, pages 186-192, 210-216, 234-252
[116] Lee 1979, *British Regional* Employment Statistics, pages 186-192, 210-216, 234-252
[117] Lee 1979, *British Regional* Employment Statistics, pages 186-192, 210-216, 234-252

Figure 4 a-d: Share of Aggregate Patenting by Region 1904-1910

Figure 4a: 1904

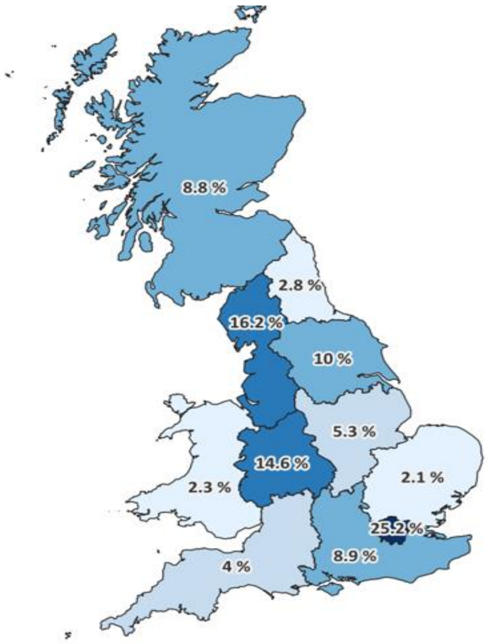


Figure 4b: 1905

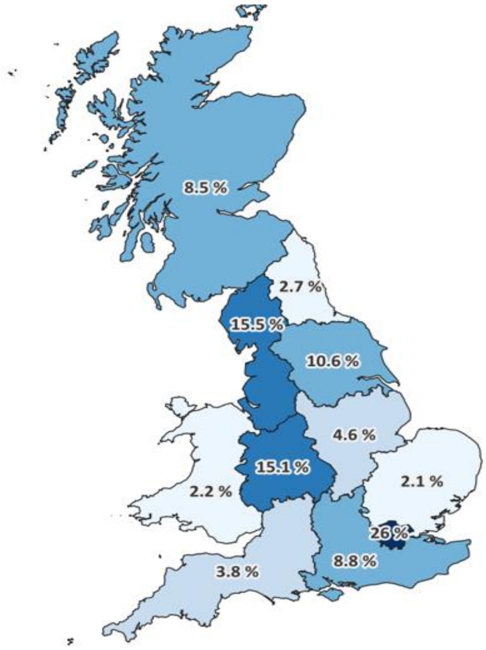


Figure 4c: 1906

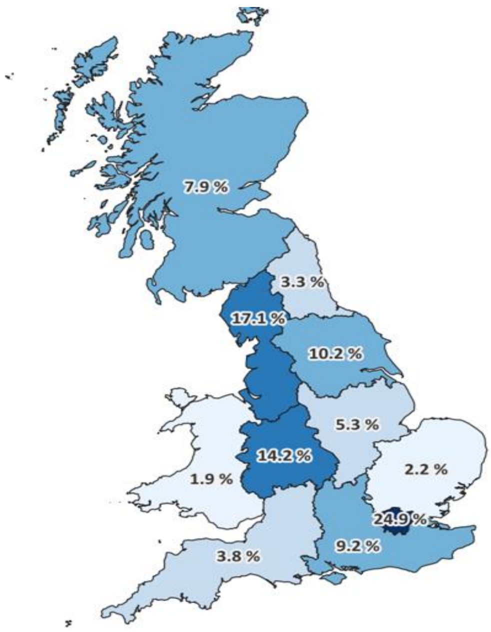
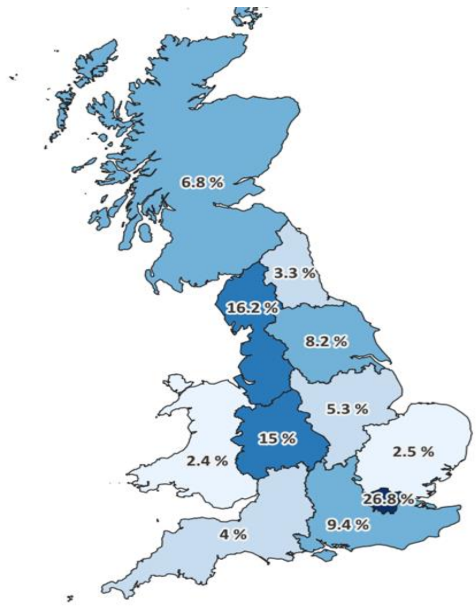


Figure 4d: 1910



Source: Bergeaud, Antonin and Verluise Cyril. "PatentCity: A Dataset to Study the Location of Patents since the 19th Century." Harvard Dataverse, 2022. https://doi.org/doi:10.7910/DVN/PG6THV; ONS Geography, "NUTS, Level 1 (January 2018) Boundaries UK BSC," Office for National Statistics, accessed March 25, 2025, https://geoportal.statistics.gov.uk/datasets/ons::nuts-level-1-january-2018-boundaries-uk-bsc/about.

Figures 5a-d: The Location of Patentees 1904-1910

Figure 5a: 1904

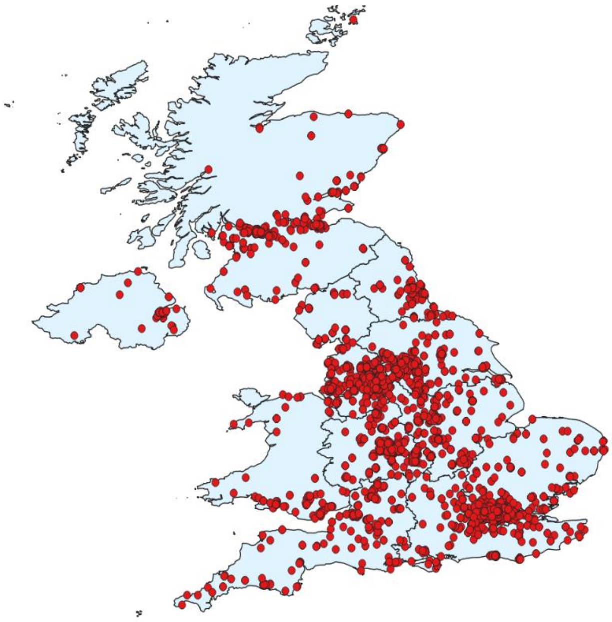


Figure 5b: 1905

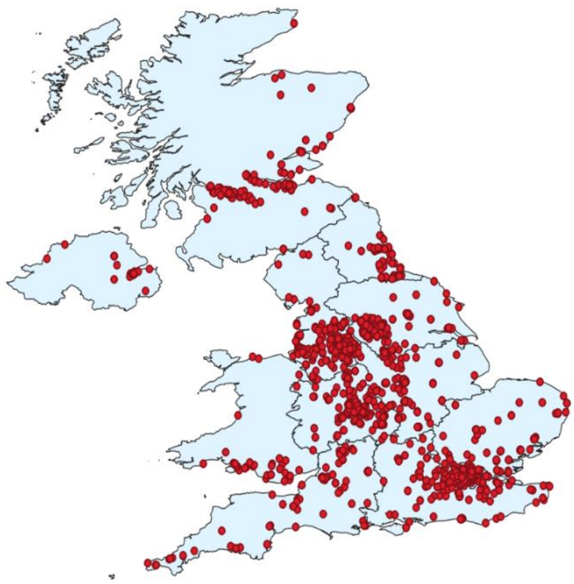


Figure 5c: 1906

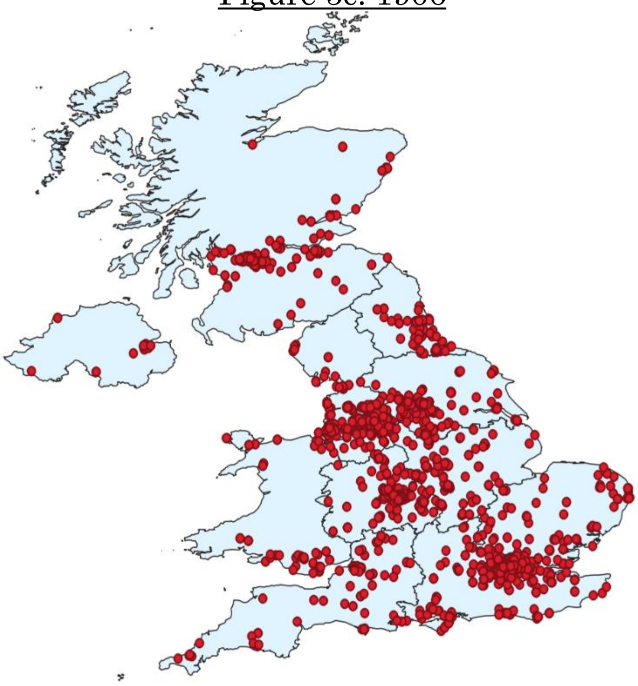
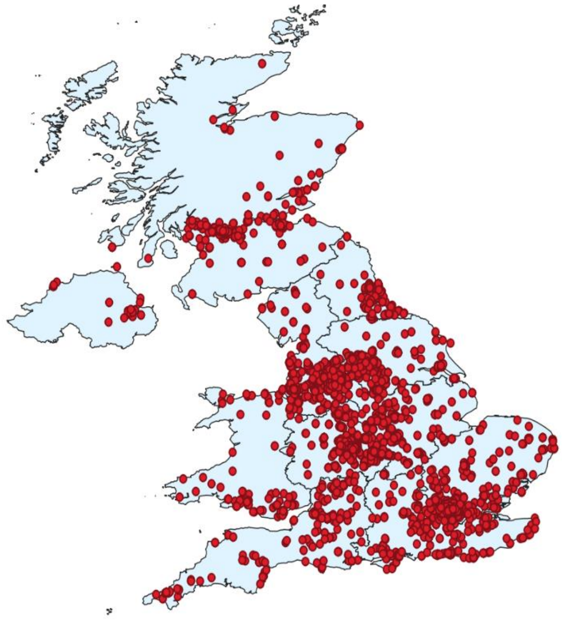


Figure 5d: 1910



Source: Bergeaud, Antonin and Verluise Cyril. "PatentCity: A Dataset to Study the Location of Patents since the 19th Century." Harvard Dataverse, 2022. https://doi.org/doi:10.7910/DVN/PG6THV; ONS Geography, "NUTS, Level 1 (January 2018) Boundaries UK BSC," Office for National Statistics, accessed March 25, 2025, https://geoportal.statistics.gov.uk/datasets/ons::nuts-level-1-january-2018-boundaries-uk-bsc/about.

Extremely evident from Figure 5 is the concentration of patenting around cities, in line with Jacobian agglomeration theories. As expected, London hosts an extremely large concentration of patenting activity in all 4 years. There are also large agglomerations of inventive activity around Liverpool, Leeds and Manchester, as well as Birmingham and Newcastle, contributing to the higher patenting shares in the West Midlands and Northwest.

Crucially, within regions, patenting activity is not evenly distributed across space. Wales is an extreme example of this where in 1904, 1905 and 1906 almost all patenting occurs in Swansea and Cardiff. A similar pattern occurs in Scotland where patenting is also concentrated in the cities of Edinburgh and Glasgow.

Interestingly Figure 5b shows that in 1905 the spatial distribution of patenting becomes more concentrated towards cities, with less dispersion throughout regions. In the Southwest there is increased concentration around Bath, Bristol and Oxford for example, although this is more dispersed again in 1906. This is also particularly prevalent in the East Midlands and Yorkshire, where most patenting activity moves towards Sheffield and Leeds. This again, is more dispersed in 1906. A further discussion of patenting in cities is provided in Appendix 3.1.

Figure 5d shows that by 1910, although still clustering around the main industrial cities, patenting is more dispersed surrounding these areas, with a visibly large general increase in inventive activity, especially in the Midlands.

While Figures 3, 4 and 5 provide a valuable visual overview of patenting trends and spatial patterns, they cannot statistically isolate the impact of the 1905 policy from other concurrent temporal or regional factors, necessitating regression analysis.

5.3 Quantitative Analysis

The quantitative analysis employs regression models to estimate the effect of the 1905 policy reform on patenting activity, building upon the descriptive insights from the previous sections.

Table 1 presents the results from the baseline pooled regression model examining the overall effect of the Post_Policy dummy with year fixed effects to account for common national time trends.

Table 1: Effect of 1905 Policy Implementation on Aggregate Patent Quantity

	Coefficient	**Std. err.**	**P-value**
Post_Policy	0.01	0.36	0.98
_cons	5.94	0.26	0
Obs	231		
F -statistic	0.99		
R^2	0.016		

Notes: Significance levels are indicated as follows: * p < 0.10, ** p < 0.05, *** p < 0.01
Source: Bergeaud, Antonin and Verluise Cyril. "PatentCity: A Dataset to Study the Location of Patents since the 19th Century." Harvard Dataverse, 2022.
https://doi.org/doi:10.7910/DVN/PG6THV

As shown in Table 1, the model explains only 1.6% of the variance in the log of patent counts across the period. This suggests that while the model includes controls for national year trends, other factors not included in this simple specification have a more significant impact on patenting rates. The coefficient for Post_Policy is very small and positive at 0.01, indicating that the policy implementation in 1905 was associated with a small increase in the log of patents sealed. However, this result is not statistically significant, with a high P-value of 0.98.

Table 2 presents the results from the baseline model including regional interactions, which examines whether the post-policy change in patenting differed across regions, including year fixed effects.

As shown in Table 2, this model explains a substantial proportion of the variance in the log of patent counts with an R^2 of 0.9722 and is highly statistically significant with an F-statistic of 347.49 and P-value < 0.001. The coefficient for the main Post_Policy dummy, 0.2438, is not statistically significant with a P-value of 0.69, indicating no significant average post-policy change across all regions relative to the base region. However, when interacting the regional dummy variables with the Post-Policy dummy, there is evidence of a differential impact across regions. The interaction term for the Southeast, 0.19, is positive and statistically significant at the 5% level. This suggests that, compared to the base region London, the Southeast experienced an approximate 19.6% increase in patents sealed. There was also a positive interaction term for Wales with a coefficient of 0.23, which is marginally statistically significant at the 10% level. This suggests Wales experienced an approximate 22.7% increase in patent quantity relative to the base region. For the other regions, the interaction terms are not statistically significant at the 5% or 10% levels, implying no statistically discernible differential policy effect in these regions compared to the base region in this model.

Table 2: Effect of 1905 Policy Implementation with Regional Interactions

	Coefficient	Std. err.	P-value
Post_Policy	0.24	0.62	0.69
Post_policy#Region			
London	_	_	_
Southeast	0.19**	0.88	0.02
East Anglia	-0.13	0.88	0.30
Southwest	-0.35	0.88	0.21
West Midlands	0.11	0.88	0.72
East Midlands	0.12	0.88	0.44
Northwest	0.51	0.88	0.56
Yorkshire & Humb.	-0.05	0.88	0.31
Northeast	0.12	0.88	0.32
Wales	0.23*	0.88	>0.05
Scotland	0.09	0.88	0.56
Obs =	231		
F -statistic =	347.49		
R^2 =	0.97		

Notes: Significance levels are indicated as follows: * p < 0.10, ** p < 0.05, *** p < 0.01
Source:; Bergeaud, Antonin and Verluise Cyril. "PatentCity: A Dataset to Study the Location of Patents since the 19th Century." Harvard Dataverse, 2022. https://doi.org/doi:10.7910/DVN/PG6THV; C.H. Lee, British Regional Employment Statistics 1841-1971 (Cambridge University Press, 1979)

Table 3 presents the results from the pooled regression model including the 28 individual industry employment controls and year fixed effects, examining the national association between industry structure and patenting.

Table 3: The effect of Industries on Patenting Activity

	Coefficient	Std. err.	P-value
Post_policy	0.6	0.37	0.10
Agriculture, Forestry and Fishing	0.18	0.15	0.25
Mining and Quarrying	-0.12	0.14	0.42
Food, Drink and Tobacco	-1.68*	0.92	0.07
Chemicals and allied Industries	0.90**	0.41	0.03
Metal manufacture	0.90***	0.27	<0.01
Mechanical engineering	-1.09***	0.31	<0.01
Instrument engineering	0.01	0.29	0.91
Electrical engineering	0.24	0.18	0.20
Shipbuilding and marine engineering	0.76	0.08	0.36
Vehicles	0.26	0.18	0.15
Metal goods not specified elsewhere	0.09	0.24	0.70
Textiles	0.16	0.12	0.17
Leather, leather goods and fur	0.37	0.47	0.44
Clothing and footwear	0.86**	0.39	0.03
Bricks, pottery, glass, cement etc	-0.55**	0.25	0.03
Timber, furniture etc	-0.06	0.59	0.92
Paper, printing and publishing	-0.10**	0.04	0.03
Other manufacturing industries	0.72***	0.20	<0.01
Construction	-0.49***	0.18	<0.01
Gas, electricity and water	0.35	0.29	0.22
Transport and communication	0.00	0.12	0.97
Distributive trades	1.14***	0.32	<0.01
Insurance, banking, finance and business services	-0.91	0.60	0.13
Professional and scientific services	0.56	0.37	0.13
Miscellaneous services	-0.02	0.05	0.61
Public administration and defence	0.11	0.26	0.68
Not classified	0.10**	0.04	0.04
Obs =	231		
F -statistic =	321.5		
R^2 =	0.9761		

Notes: Significance levels are indicated as follows: * p < 0.10, ** p < 0.05, *** p < 0.01
Source: Bergeaud, Antonin and Verluise Cyril. "PatentCity: A Dataset to Study the Location of Patents since the 19th Century." Harvard Dataverse, 2022. https://doi.org/doi:10.7910/DVN/PG6THV; C.H. Lee, British Regional Employment Statistics 1841-1971 (Cambridge University Press, 1979)

Given the importance of industry-specific characteristics for patenting activity, it is important to examine how changes in economic activity, proxied by employment rates, are associated with patenting rates nationally. As shown in Table 3, this model explains a very high proportion of the variance in patenting activity with an R^2 of 0.9761 and is highly statistically significant overall. The coefficient for the Post_Policy dummy of 0.6, is positive but only marginally statistically significant with a P-value of 0.104, corresponding to an approximate 60% increase in patent quantity nationally, however this effect is not robustly significant.

Table 3 shows multiple industries whose employment levels are statistically significantly associated with patenting rates in this period. For example, a 1% increase in employment in Chemicals and Allied Industries is associated with an approximate 0.9% increase in patenting activity, statistically significant at the 5% level. Employment increases in Clothing and Footwear and Other Manufacturing Industries are also positively associated with patenting, significant at the 5% level. Both Metal Manufacture and Distributive Trades show a positive and statistically significant association at the 1% level, with approximate 0.89% and 1.14% increases respectively for a 1% increase in employment. Employment in the 'Not Classified' category also shows a small but statistically significant positive association, which is plausible given the mix of occupations within this category that may include potential patentees.

Some industries show a statistically significant negative association with patenting. A 1% employment increase in Mechanical Engineering is associated with an approximate 1% decrease in patenting, significant at the 1% level. Construction employment shows a similar negative association, with a 0.49% decrease for a 1% increase in employment, significant at the 1% level. Employment in Bricks, Pottery & Glass, and Paper, Printing & Publishing shows a small but statistically significant negative association. Food, Drink and Tobacco shows a larger negative association, with a 1% increase in employment corresponding to a 1.67% decrease in patents sealed, although this is only marginally significant.

While the specific coefficients for industry employment in Table 3 are not the primary focus for assessing the policy's direct impact, they are valuable in highlighting the substantial differences in patenting activity across industries. This is particularly relevant as these industries are often agglomerated across space, a factor that may contribute to the observed heterogeneity in regional patenting patterns and provides essential context for the regional analysis. However, it is important to note that making significant causal links between industrial employment levels and patenting activity from these associations is difficult. As discussed in the methodology and Appendix 2.2, potential endogeneity issues exist, including reverse causality with invention attracting employment, and omitted variable bias from unobserved factors driving both. As previously discussed, it was also not possible to include interaction terms between the policy and individual industries due to multicollinearity. A discussion of the composition of patentee occupations across these employment categories from the patent sample can be found in Appendix 3.2

Tables 4 a and b present the results from the primary analysis: individual regional regressions for the South East and Wales, which include region-specific aggregated industry employment controls and year fixed effects.

Tables 4 a&b: The Effect of the 1905 Policy Implementation on Quantity of Patents Sealed within each Region, with Industry Employment Controls

(a) South East			
	Coefficient	**Std. err.**	**P-value**
Post_policy	0.01	0.17	0.95
Industry Group 1	-55.08	99.73	0.59
Industry Group 2	11.18	11.97	0.37
Industry Group 3	48.03	75.67	0.54
Industry Group 4	-15.23	13.78	0.29
Industry Group 5	1.67	1.85	0.38
Industry Group 6	0.65	0.38	0.11
obs =	21		
F -statistic =	0.0091		
R^2 =	0.7102		

(b) Wales			
	Coefficient	**Std. err.**	**P-value**
Post_policy	-0.27	-0.31	0.40
Industry Group 1	-700.62	1496.89	0.65
Industry Group 2	745.88	1287.89	0.57
Industry Group 3	-18.28	51.44	0.73
Industry Group 4	-519.08	823.88	0.54
Industry Group 5	762.14	1479.91	0.62
Industry Group 6	-0.26	0.30	0.42
obs =	21		
F -statistic =	0.1167		
R^2 =	0.531		

Notes: Significance levels are indicated as follows: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Source: Bergeaud, Antonin and Verluise Cyril. "PatentCity: A Dataset to Study the Location of Patents since the 19th Century." Harvard Dataverse, 2022. https://doi.org/doi:10.7910/DVN/PG6THV; C.H. Lee, British Regional Employment Statistics 1841-1971 (Cambridge University Press, 1979)

As shown in Table 4a, for the Southeast, when controls for aggregated industrial employment are included, the Post_Policy coefficient is positive, but very small and statistically insignificant. Similarly, for Wales in table 4b, the coefficient for Post_Policy is-0.27, which is negative but not statistically significant with a P-value of 0.40. These results would imply that, after accounting for region-specific industry mix and year trends, the policy had no statistical impact on patenting levels in these regions.

The coefficients for the aggregated industry controls in these regional regressions are notable for their unusually large magnitudes (e.g., -55.08, 745.88, -700.62). While these coefficients are presented as estimated by the model, interpreting them as standard percentage changes is not meaningful due to their extreme size. Their magnitude may reflect the complexity of modelling patenting using aggregated industry employment within specific regional time series with the available data, or potential underlying data/variable construction challenges unique to these regional subsets. Despite the unusual magnitude of these control coefficients, the key finding from these models remains the lack of statistical significance for the Post_Policy variable in both regions.

While none of the industry controls are statistically significant in the specific models for the Southeast and Wales shown, the overall R^2 values indicate that the aggregated industry controls and year fixed effects do explain a substantial portion of the variance in patenting within these regions. This suggests that changes in patenting within these regions are more likely explained by general economic changes or other time-varying factors captured by the controls, rather than the policy.

As expected, based on the findings from Table 2 and the lack of statistically significant regional interactions for other regions, there were also no statistically significant effects of the policy in any other region in the individual regressions. The tables for these regressions can be found in Appendix 3.3. Some regions did have statistically significant aggregated industry control groups. For example, as seen in Appendix 3.3, in London, East Anglia and the West Midlands the 'Industry Group 1' control was significant at the 10% level. In the Southwest, Industry Groups 2 and 3 had a statistically significant effect on patenting at the 5% and 1% levels respectively. However, since these aggregated groups are comprised of different industries in each region, comparisons of coefficients across regions for the same 'Industry Group' number cannot be made.

Overall, the results of the individual regional regressions consistently show that the policy had no statistically significant effect on patenting activity within any specific region, even after accounting for region-specific industry mix and time trends.

<u>5.4 Robustness Checks</u>

The results of repeating the analysis for the 1907 policy change show largely similar outcomes, strengthening the main conclusions. The results for these can be seen in Appendix 4.

For the pooled model with regional interactions, the overall model is highly significant, with a high F-statistic. The Southeast and Wales both show statistically significant interactions with the Post_Policy dummy starting from 1908. In the Southeast, the policy is associated with a 0.19 increase in log patents sealed, significant at the 5% level, corresponding to an approximate 20.9% increase in patent quantity. In Wales, the policy is associated with a 0.24 increase in log patents sealed, statistically significant at the 1% level, corresponding to an approximate 27.1% increase. As in the main analysis, the other regions experienced no statistically significant differential impacts from the policy starting in 1908 in this pooled model.

The repetition of the individual regional regressions for the 1907 policy period also yielded similar results as the main analysis for the lack of a statistically significant policy effect within specific regions. For the Southeast, the Post_Policy coefficient is very small and negative, but statistically insignificant.

In this model, the Industry Group 6 control was marginally statistically significant at the 10% level, implying a positive association. In Wales, the Post_Policy coefficient is very small, positive, and statistically insignificant. None of the industrial employment controls were statistically significant in the Welsh model. Repetition for the other regions also shows no statistically significant impact of the policy on patenting activity within each region during the 1908-1913 period.

Overall, the robustness checks confirm the main findings that the 1905 policy change, or the subsequent 1907/1908 change, had no significant impact on regional patenting activity.

Section 6: Discussion

The results presented in Section 5 highlight that, overall, the 1902 Policy, which introduced an examination for novelty in the patent system in 1905, did not have a statistically significant impact on the regional distribution of patenting activity in Britain. This primary finding remained consistent and robust when the analysis was repeated using the later 1907 policy change as the treatment period. This conclusion aligns with findings by Nicholas (2011) regarding the limited distributional effects of the 1883 Patent Policy Reform, suggesting that major changes to the British patent system in this era may not have immediately or substantially altered the geographic distribution of invention. The lack of statistically significant regional effects from a policy that increased costs and changed incentives for patenting has interesting implications.

Given theoretical predictions about the potential for such a policy to increase patent quality, in the context of regional inequalities in inventive activity, it is noteworthy that no region experienced a statistically significant decline in patenting post-policy in the main analysis. A significant decline might have suggested that prior regional patenting levels were inflated by a high concentration of low-value inventions easily filtered out by examination. The absence of this suggests this may not have been the case across entire regions. It is plausible that the policy's overall effect on the *number* of patents was ambiguous due to simultaneous but opposing effects on different types of inventors. Some inventors may have been incentivised to patent more due to the increased legal certainty and decreased risk of infringement associated with an examined patent. Conversely, inventors with less novel inventions may have been discouraged, anticipating their applications would fail examination. These counteracting forces could explain the increase in patent quality found by Billington et al. (2025) while resulting in a statistically ambiguous effect on the total count of patents observed in this study at the regional level.

Although some regions did experience fluctuations in their aggregate patent counts and relative shares around 1905, as shown in Figures 4 and 5, the highly cyclical nature of patenting across regions in the early 20th Century suggests these fluctuations may be part of broader temporal patterns rather than a direct, significant policy impact. Furthermore, while the spatial distribution of patenting within regions appeared to become more concentrated around cities temporarily in 1905, as illustrated in Figure 5, this pattern seemed to equalise quickly by 1910. While the impact of the distribution of patentees *within* regions is an important avenue for future research, the scope and data limitations of this study prevent definitive conclusions about whether this temporary spatial shift was a direct policy effect or an artefact of the data.

However, it is possible that the policy did have an effect on some regions, but this effect was statistically masked or counteracted by other significant regional-level forces. Industrial growth and changes in regional industry composition are likely candidates for such forces, given their known importance for patenting activity and the significant associations observed in the pooled analysis in Table 3. Disentangling the specific effect of the policy from the influence of these ongoing industrial dynamics within this analysis is challenging, particularly due to the lack of industrial classification for individual patents within each region, which would be necessary to analyse the policy's effect on specific industries or types of inventions at the regional level.

Given this, the lack of a statistically significant policy effect in the regional regressions suggests that changes in regional patenting activity were likely influenced more by underlying industrial growth and economic trends than by the policy. To further explore the potential role of these factors, I examine supplemental evidence from regional employment and patentee occupation data, although limitations in this data, discussed in Appendix 1.2, mean any links remain suggestive rather than causal.

For instance, while the Southeast showed a statistically significant increase in patenting activity in the baseline regression with regional interactions in Table 2, this effect became statistically insignificant when controls for region-specific aggregated industry employment were added in the individual regional regression in Table 4a. This suggests that the initial observed difference might have been associated with the South East's specific industrial composition or other factors captured by the controls. Moderate growth in overall patenting activity in the Southeast from 1901 to 1910, with an average annual increase of 29 patents, supports the idea of underlying positive trends.[118] The robustness check for the Southeast showed that the aggregated Industry Group 6 control was marginally statistically significant. This group includes Public Administration and the 'Not Classified' employment categories. The 'Not Classified' category, while ambiguous, covers professions like machinists, merchants, and managers who are likely patentees. Employment in 'Not Classified' increased by nearly 8,000 in the Southeast between 1901 and 1911, and occupation data shows patentees in 'Not Classified' roles increased significantly from 743 to 1971 between 1906 and 1910, comprising the second largest source of patentees in the region.[119] Public Administration employment also increased significantly by 36%, although its contribution to patenting was

[118] *Bergeaud and Verluise 2022, "New Dataset,"*
[119] Lee 1979, *British Regional* Employment Statistics, pages 186-192, 210-216, 234-252; Bergeaud and Verluise 2022, "New Dataset,"

minimal, accounting for only 2 patents with occupation data.[120] Other high-patenting sectors like Electrical and General Engineering saw their numbers of patentees double between 1904 to 1910.[121] This supplemental data supports the plausibility that underlying growth and shifts within specific occupational groups, captured imperfectly by the aggregated industry controls, were significant drivers of patenting trends in the Southeast, making it difficult to isolate a policy effect in the regional regression.

Similarly, for Wales, the policy coefficient in the individual regional regression in Table 4b was not statistically significant. Occupation data for Wales shows a substantial increase in patentees in Professional and Scientific Services, 270% from 1904 to 1910, or 164% from 1906 to 1910 when accounting for data coverage limitations from Appendix 1.2, particularly among general engineers.[122] While data issues prevent causal claims, this suggests an upward trend in occupations associated with patenting that could explain the increase in overall patenting activity in Wales which increased from 66 patents in 1901 to 160 in 1910, despite fluctuations, potentially overshadowing any policy effect in the regression analysis.[123] This indicates that general economic and occupational trends were likely more influential for patenting in Wales than the 1905 policy.

For other regions, the individual regional regressions also consistently showed no statistically significant policy effect. However, some aggregated Industry Control Groups were statistically significant in these models, for example in London, East Anglia, the West Midlands, and the Southwest, reinforcing that industry-level changes matter for patenting levels within regions. In the South West, for example, the significant coefficient for Industry Group 3, which includes Professional and Scientific Services, aligns with occupation data showing an 18% increase in patentees in this category between 1906 and 1910.[124]

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[120] Bergeaud and Verluise 2022, "New Dataset,"; C Lee 1979, *British Regional* Employment Statistics, pages 186-192, 210-216, 234-252
[121] Bergeaud and Verluise 2022, "New Dataset,"
[122] *Bergeaud and Verluise 2022, "New Dataset,"*
[123] Bergeaud and Verluise 2022, "New Dataset,"
[124] Bergeaud and Verluise 2022, "New Dataset,"

This category comprised nearly 40% of patenting activity in the South West by 1906.[125] Data limitations prevent causal claims; occupation data in the South West covers only 44-60% of all patents as shown in Appendix 1.2.[126] However this external evidence does further support the idea that changes in key patenting-related occupations and industries likely drove patenting trends in regions like the Southwest, potentially explaining the lack of a detectable policy effect in the regression.

It is important to reiterate that the coefficients for the aggregated industry control groups in these regional regressions in Tables 4 a&b and in Appendix 3.3 are, in many cases, unusually large. As discussed in Section 5.3, these magnitudes are not interpreted as standard percentage changes and likely reflect the challenges of modelling complex relationships with aggregated variables. Despite these complexities in interpreting the control variables, the consistent lack of statistical significance for the Post_Policy variable across all regional models remains the key finding.

It is also possible that there wasn't sufficient time within the study period to observe the long-term effects of the policy before inventive activity was significantly disrupted by World War 1 from 1914. However, given that historical analysis of previous patent reforms in the late 19th century often shows relatively immediate reactions in terms of application numbers, a significant delayed effect from the 1905/1907 policy on regional totals seems less likely, though not entirely impossible without a longer time series.

Overall, this research suggests that while the 1905 examination policy, and the subsequent 1907 Act, likely influenced the quality of patents, it did not have a statistically significant impact on the regional distribution or the total quantity of patents sealed within specific British regions between 1905 and 1913. The observed regional patterns and changes during this period appear to be more

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[125] Bergeaud and Verluise 2022, "New Dataset,"; Lee 1979, *British Regional* Employment Statistics, pages 186-192, 210-216, 234-252
[126] Bergeaud and Verluise 2022, "New Dataset,"

closely associated with underlying industrial structure and general economic dynamics, which future research with more granular data, such as patent classification by industry, could further explore to better disentangle these effects. The exploratory analysis using occupation data supports the plausibility that changes in patenting-relevant occupations within regions were significant drivers of regional patenting trends during this period.

Section 7: Conclusion

This paper investigated the effect of the 1902 British patent policy, which introduced a novelty examination and increased application costs, on the quantity of patents sealed across British regions during the early 20th Century. Theoretically, this policy was expected to alter inventors' incentives, increasing patent quality by encouraging the patenting of more robust inventions while discouraging low-quality, unoriginal inventions. The 25% cost increase, equivalent to over £100 today, might also have disproportionately affected credit-constrained inventors, potentially leading to larger decreases in patenting in less affluent regions. Analysing geocoded patent data from the PatentCity dataset, the study employed panel regression analysis with regional and temporal controls to empirically test the policy's impact on regional patenting quantity and distribution.

The central empirical finding of this research is that the 1905 policy implementation did not have a statistically significant impact on the regional distribution or the quantity of patents sealed within specific British regions during the study period. While initial pooled regressions with regional interactions showed some statistically significant differential changes for the Southeast and Wales, this regional impact became statistically insignificant for all regions when controlling for region-specific aggregated industry employment and year fixed effects in the individual regional regressions. The analysis of the overall aggregate quantity of patents also found no statistically significant effect associated with the policy change. These findings were consistent and robust

when the analysis was repeated using the later 1907 policy change as the treatment period.
Despite the lack of a statistically significant regional quantitative impact, this result carries important implications. The fact that no region experienced a statistically significant decline in patenting activity, despite the increase in costs and the introduction of more stringent examination, is notable. This suggests that, at the regional level, pre-policy patenting activity may not have been uniformly inflated by low-quality inventions easily deterred by the reform, or that any discouraging effects were offset by other factors. The finding that this policy had no discernible distributional effects at the regional level is particularly interesting when compared to other reforms. For instance, Nicholas (2011) also found no significant regional impact on the overall quantity of patenting following the 1883 reform, which dramatically *decreased* costs. This could imply that, in this historical context, regional patenting levels were relatively less sensitive to moderate changes in the cost or examination requirements compared to other, more fundamental regional-level economic and industrial factors.

This study faced limitations that warrant consideration and suggest avenues for future research. The lack of readily available data linking individual patents to specific technological classifications within regions limited the ability to analyse the policy's impact on invention in specific industries or types of technologies at the regional level, which would be crucial for a more granular understanding. Furthermore, while the study utilised regional employment and exploratory patentee occupation data to provide supplemental context for potential drivers of regional patenting trends, limitations in the granularity and coverage of this data, along with inherent endogeneity challenges, prevent definitive causal conclusions about the interplay between the policy and regional economic factors.

Despite these limitations, the research offers valuable insights. The observed pattern of spatial concentration of patentees around cities in 1905 in Figure 5b, even if temporary, is an interesting descriptive finding that suggests potential within-region dynamics around the policy change. Future research, potentially utilising more granular spatial data and more sophisticated spatial analysis, could explore within-region or urban-rural effects of the policy, contributing to the literature on cities as sites of innovation. Furthermore, while quantitative analysis was limited by data availability, future research using more comprehensive data on inventor occupations could investigate whether the policy systematically changed who was inventing and patenting, potentially shifting the composition of patentees towards certain professions more likely to navigate or benefit from novelty examination.

Upon reflection, the persistence of regional patenting activity levels, despite the increased costs and stricter regulation introduced by the 1905 policy, likely reflects the robustness of the industrial economic structures and underlying drivers of invention in British regions during the early 20th century. Overall, this research concludes that the 1902/1905 patent reform did not have a statistically discernible redistributive effect on the quantity of patenting across British regions, suggesting that regional patterns of invention were primarily shaped by deeper economic and industrial characteristics during this period.

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Appendix

Appendix 1: Data

A1.1 The PatentCity Sample

Table A1: The Share of Total Patents captured by the PatentCity Sample

Year	PatentCity Geocoded Total	Patent Office Report Total	Proportion of Total patents in PatentCity sample (%)	Estimated % of Domestic Patents in Sample
1895	4811	12346	38.97	77.94
1896	5009	15170	33.02	66.04
1897	5808	14465	40.15	80.30
1898	5810	13425	43.28	86.55
1899	5103	13298	38.37	76.75
1900	5321	13170	40.40	80.80
1901	4155	13062	31.81	63.62
1902	4802	13764	34.89	69.78
1903	5507	15718	35.04	70.07
1904	5118	15089	33.92	67.84
1905	5272	14746	35.75	71.50
1906	5398	14707	36.70	73.41
1907	5611	16272	34.48	68.97
1908	5483	16284	33.67	67.34
1909	5928	15065	39.35	78.70
1910	6531	16269	40.14	80.29
1911	6256	17164	36.45	72.90
1912	5508	15814	34.83	69.66
1913	5763	16599	34.72	69.44
1914	5238	15036	34.84	69.67
1915	4259	_	_	_

Despite including all geocoded patents in the PatentCity dataset, this does not account for all patents sealed across the period. As previously discussed, due to the digital transcription not all patents had a geocoded entry on the dataset, hence the sample used in my analysis does not include all patents. The 4th column of Figure A1 shows that the PatentCity sample accounts for between around 33-43% of total patents sealed at the Patent Office.

However, the final column in Table A1 accounts for the fact that the total figures given by the Patent Office include all patentees, not just domestic inventors. Given that my analysis only covers domestic inventors, I recalculated the percentage of total patents covered by the PatentCity sample using an estimation of the proportion of domestic inventors in the total sample. The 1908

Patent Office Comptrollers Report breaks down the location of patentees at the country-level for the years 1904-1908.[127] From this, I calculated the percentage of sealed patents granted to domestic inventors. The average from this period was around 50%, with the highest proportion of patents to domestic inventors in 1905 at 54%.[128] I am aware that the proportion of patents granted to domestic patentees would have likely fluctuated throughout the wider period, however this gives some indication of how reliable my sample is generally.

The final column in Table A1 shows that the PatentCity sample accounts for around 66-86% of total patents when only accounting for domestic inventors. Although this does fluctuate between years, the overall sample average is 73%. Given that the estimations were based upon the years 1904-1908 and the average is 70%, with minor variations, it is likely that the wide range in percentages across the whole period is due to fluctuations in numbers of domestic inventors. This can occur due to market conditions in Britain and abroad, foreign policy and other factors that lie outside the Patenting System. However, overall, the high share of patents covered and geocoded by the PatentCity database is promising.

Given that the Patent Office Reports do not report regional distributions at any point, I am however, unaware of how representative the PatentCity sample is at the regional level. I therefore have to assume that the patents not geocoded in the PatentCity sample are randomly distributed across space. However, given the generally high representativeness of the sample, there are no major concerns that this would not be the case.

A1.2: Occupation Data

Table A2: Representativeness of Occupation Data: % of Total PatentCity sample including Occupation data 1904-1910

Region	**1904 (%)**	**1906 (%)**	**1910 (%)**
London	35.61	42.94	35.79
Southeast	47.46	63.33	66.72
East Anglia	39.05	42.02	26.38
Southwest	48.77	43.90	59.85
West Midlands	62.48	63.33	63.53
East Midlands	48.71	51.58	60.69
Northwest	56.71	56.68	57.88
Yorkshire and Humberside	54.59	56.57	59.14
Northeast	59.31	62.01	53.92
Wales	31.62	59.22	60
Scotland	55.36	60.14	66.22
Total	47.56	54.20	53.68

Source: Bergeaud, Antonin and Verluise Cyril. "PatentCity: A Dataset to Study the Location of Patents since the 19th Century." Harvard Dataverse, 2022. https://doi.org/doi:10.7910/DVN/PG6THV

[127] Comptroller Reports 1908, page 14
[128] Comptroller Reports 1908, page 14

Appendix 2: Methodology

A2.1 London and the Southeast

Table A3: Patenting and Economic Activity in London and the Southeast (1901)

Region	Population	Patent Count	Agriculture Employment	Shipbuilding and Marine Engineering Employment	Paper Printing and Publishing Employment
London	4,536,541	1,334	13,525	4,281	91,037
Southeast (excluding London)	5,959,004	378	304,504	12,338	36,574

Source: Bergeaud, Antonin and Verluise Cyril. "PatentCity: A Dataset to Study the Location of Patents since the 19th Century." Harvard Dataverse, 2022. https://doi.org/doi:10.7910/DVN/PG6THV; C.H. Lee, British Regional Employment Statistics 1841-1971 (Cambridge University Press, 1979), pp 186-192, 210-216, 234-252

As shown in Table A3, the share of patenting and economic activity varies significantly between London and the rest of the Southeast. In 1901 London had a large population, and although smaller than the rest of the Southeast, it had over 3.5 times more patents sealed. Furthermore, the economic base of London was considerably different as expected and reflected in the last 3 columns of Table A3.

A2.2 Multicollinearity of Industry Controls

It was not possible to carry out a regression with industry interactions due to the large presence of multicollinearity in employment in different industries. This inflates the standard errors and makes it difficult to determine the effect of the controls on patenting activity. The high multicollinearity is expected, to an extent, due to the nature of the employment data. The data is linearly interpolated from three data points from the censuses, which can artificially introduce linear trends between the variables.

I used the Variance Inflation Factor (VIF) to detect this multicollinearity, and a VIF of over 10 for most variables severely compromised the validity of this regression. To address this issue, I attempted to group highly collinear employment variables together into composite groups. I did this both based off statistical correlation matrices and related industry classifications, for example, industries associated with mining and metals grouped together. I also excluded variables with the highest VIF values, however I could not remove multicollinearity from this model

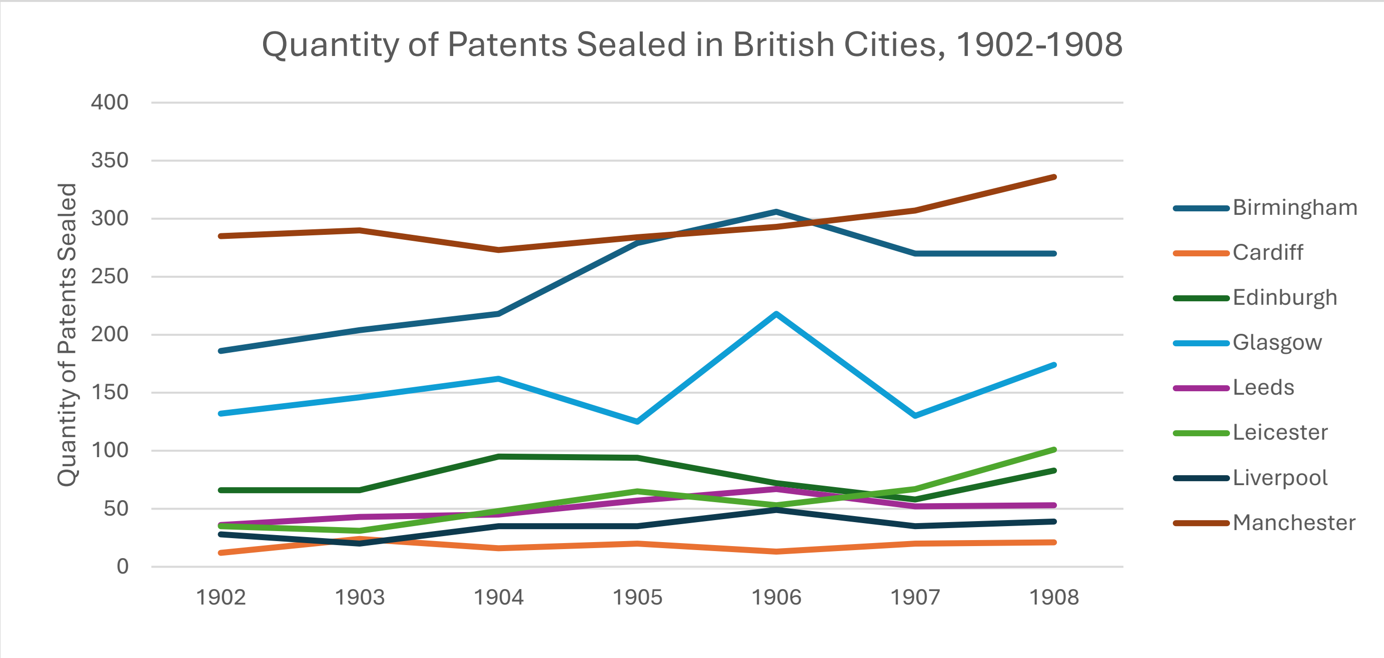
A2.3 Regional Employment Control Groups

At the regional-level, I re-ran the correlation matrices discussed above in Appendix 2.2 and combined these industries into groups based on these results. I could not use the same groups for every region due to the region-specific nature of employment composition. While these region-specific groups prevent direct comparison of industry group effects across regions and their aggregated nature makes interpreting individual industry impacts within regions challenging, they serve as the best available control for region-specific industry composition given the multicollinearity issues with individual industries.

Appendix 3: Additional Material for Main Analysis

A3.1 Cities and Inventive Activity

Figure A1 City-level Analysis



Source: Bergeaud, Antonin and Verluise Cyril. "PatentCity: A Dataset to Study the Location of Patents since the 19th Century." Harvard Dataverse, 2022. https://doi.org/doi:10.7910/DVN/PG6THV

As shown in Figure A1 there are no clear uniform changes in the number of patents registered to cities around the 1905 policy implementation. Glasgow experiences some clear fluctuations in the period, with a significant decrease in patenting in 1905. However, due to subsequent fluctuations this likely is not significant. Edinburgh and Leicester experienced a minor decline post-1905, while Liverpool and Birmingham continued upward trends. The data geocoded to cities in the PatentCity dataset may however not be a true representation of actual patenting occurring in cities due to large inaccuracies in the filing or transcription of the patent. Many patents are assigned locations in the city column that are not cities, and many are not assigned a city but would be in a city from their coordinates. Therefore, for a more accurate analysis of the effect of these patent policies on cities, more work would need to be done on the classification of coordinate points rather than using those recorded as in cities in the PatentCity dataset. Given this is beyond the scope of this research, an analysis such as Nicholas' (2011) of cities would be an interesting area for further research.[129]

A3.2: Occupation Analysis

Analysis of patentee occupation data from the PatentCity dataset, manually extracted for 1904, 1906 and 1910 (approx. 9,000 patents), provides supplementary insights into inventor characteristics. It is crucial to note the significant limitations of this data due to transcription inaccuracies and low representativeness compared to the total patent count, preventing causal claims or definitive conclusions.

Analysis of this limited sample reveals some interesting trends, although no causal claims can be made. The proportion of patentees identifying as engineers increased from 44.25% in 1904 to 46.9% by 1906, highlighting their high representation among patentees with available occupation data and suggesting a potential increase over time. This could weakly align with the idea of the novelty examination encouraging high-skilled inventors, but definitive conclusions are impossible given the data's limitations.

The regional distribution of engineers also varies. London held 23% of engineers in 1906, an increase from 21% in 1904, while the Northwest hosted the second largest proportion (18% in 1904, 16% in 1906). The number of self-identifying engineers increased in most regions between 1904 and 1906, except in Scotland. Wales had the lowest number, just over 1% of the total 1904 sample, remaining relatively stagnant.

More generally, patentee occupations show an extremely unequal distribution. As shown in Table A2, Professional and Scientific Services account for a large proportion of patentees, 35% in 1904 and 38% in 1906. Approximately 60% within this category are general professional engineers, likely driving this high proportion. These observations provide some descriptive context related to the statistically significant association of industries like 'Professional and Scientific Services' and engineering-related manufacturing seen in the national regressions (Table 3), reinforcing that these fields are key sources of formal invention. However, the low representativeness and transcription artifacts of the occupation data prevent making strong links or causal claims.

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[129] Nicholas 2011, "Cheaper Patents," Page 325

Table A4: Count of Patentees within each employment category 1904-1910

Count of Employment	1904	1906	1910	Total
Agriculture, Forestry and Fishing	4	11	20	35
Mining and Quarrying	27	40	41	108
Food, Drink and Tobacco	28	41	37	106
Chemicals and allied Industries	58	69	90	217
Metal manufacture	43	31	35	109
Mechanical engineering	162	151	160	473
Instrument engineering	20	20	23	63
Electrical engineering	149	189	218	556
Shipbuilding and marine engineering	22	30	23	75
Vehicles	27	19	54	100
Metal goods not specified elsewhere	51	44	42	137
Textiles	40	33	35	108
Leather, leather goods and fur	17	10	14	41
Clothing and footwear	39	28	34	101
Bricks, pottery, glass, cement etc	10	17	12	39
Timber, furniture etc	19	14	33	66
Paper, printing and publishing	41	49	21	111
Other manufacturing industries	25	26	27	78
Construction	59	73	101	233
Gas, electricity and water	10	20	12	42
Transport and communication	12	21	14	47
Distributive trades	1	3	1	5
Insurance, banking, finance and business services	910	1144	1359	3413
Professional and scientific services	40	57	70	167
Miscellaneous services	3	2	3	8
Public administration and defence	683	743	971	2397
Not classified	6	9	3	18
Could not classify/illegible	27	30	53	110
Total	**2533**	**2924**	**3506**	**8963**

Source: Bergeaud, Antonin and Verluise Cyril. "PatentCity: A Dataset to Study the Location of Patents since the 19th Century." Harvard Dataverse, 2022. https://doi.org/doi:10.7910/DVN/PG6THV

A3.3 Quantitative Analysis: Regressions

Table A5: Additional Regression Tables for Quantitative Analysis

London

	Coefficient	**Std. err.**	**P-value**
Post_policy	-0.60	1.18	0.62
Industry Group 1	25.45*	13.21	0.08
Industry Group 2	-11.89	13.26	0.39
Industry Group 3	12.45	9.44	0.21
Industry Group 4	-8.17	16.53	0.63
Industry Group 5	9.36	19.17	0.63
Industry Group 6	-0.43	2.89	0.88
obs =	21		
F -statistic =	0.0457		
R^2 =	0.6107		

East Anglia

	Coefficient	**Std. err.**	**P-value**
Post_policy	0.60	0.16	0.72
Industry Group 1	-601.84*	288.84	0.06
Industry Group 2	39.03	24.19	0.13
Industry Group 3	41.22	203.80	0.84
Industry Group 4	-172.95	221.99	0.45
Industry Group 5	692.93*	331.32	0.06
Industry Group 6	-88.92	95.65	0.37
obs =	21		
F -statistic =	0.0401		
R^2 =	0.6202		

Southwest

	Coefficient	**Std. err.**	**P-value**
Post_policy	0.02	0.15	0.90
Industry Group 1	0.54	7.01	0.94
Industry Group 2	-46.40**	21.19	<0.05
Industry Group 3	29.60***	10.14	<0.01
Industry Group 4	2.99	5.40	0.59
obs =	21		
F -statistic =	0.1445		
R^2 =	0.3945		

West Midlands

	Coefficient	**Std. err.**	**P-value**
Post_policy	0.04	0.18	0.82
Industry Group 1	-19.96*	10.83	0.09
Industry Group 2	11.38	8.31	0.19
Industry Group 3	-0.30	0.79	0.71
Industry Group 4	1.83	3.00	0.55
obs =	21		
F -statistic =	0.07		
R^2 =	0.4586		

East Midlands			
	Coefficient	Std. err.	P-value
Post_policy	-0.46	-0.14	0.74
Industry Group 1	372.42	237.08	0.14
Industry Group 2	248.79	185.52	0.20
Industry Group 3	17.70*	10.02	<0.10
Industry Group 4	-409.70	247.91	0.12
Industry Group 5	-40.63	158.99	0.80
Industry Group 6	-87.95	108.94	0.43
obs =	21		
F -statistic =	0.0194		
R^2 =	0.06679		

Northwest			
	Coefficient	Std. err.	P-value
Post_policy	-0.41	0.13	0.76
Industry Group 1	-382.86	534.34	0.49
Industry Group 2	840.02	853.86	0.34
Industry Group 3	71.30	90.96	0.26
Industry Group 4	-544.25	499.00	0.30
Industry Group 5	323.26	338.35	0.36
Industry Group 6	232.65	228.96	0.33
obs =	21		
F -statistic =	0.0128		
R^2 =	0.692		

Yorkshire and Humberside			
	Coefficient	Std. err.	P-value
Post_policy	0.23	-0.17	0.21
Industry Group 1	334.78	199.40	0.12
Industry Group 2	-208.79	190.05	0.29
Industry Group 3	-32.96	26.62	0.24
Industry Group 4	30.00	19.41	0.15
Industry Group 5	-184.76	11-.9623	0.12
Industry Group 6	-222.22	461.15	0.64
obs =	21		
F -statistic =	0.2279		
R^2 =	0.4586		

Northeast			
	Coefficient	Std. err.	P-value
Post_policy	0.13	0.16	0.41
Industry Group 1	128.65	869.52	0.89
Industry Group 2	271.97	2020.75	0.90
Industry Group 3	15.66	31.57	0.63
Industry Group 4	-306.13	1518.52	0.84
Industry Group 5	22.93	30.20	0.46
Industry Group 6	-54.38	62.55	0.60
obs =	21		
F -statistic =	0.061		
R^2 =	0.5884		

Scotland			
	Coefficient	**Std. err.**	**P-value**
Post_policy	-0.01	0.98	0.95
Industry Group 1	1070.79*	1241.38	0.40
Industry Group 2	-791.07	397.30	0.07
Industry Group 3	11.71	34.01	0.74
Industry Group 4	211.27	138.69	0.15
Industry Group 5	-708.10	930.61	0.46
Industry Group 6	154.54*	81.49	0.08
obs =	21.00		
F -statistic =	0.02		
R^2 =	0.665		

Notes: Significance levels are indicated as follows: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. industry groups different for each region
Source: Bergeaud, Antonin and Verluise Cyril. "PatentCity: A Dataset to Study the Location of Patents since the 19th Century." Harvard Dataverse, 2022. https://doi.org/doi:10.7910/DVN/PG6THV; C.H. Lee, British Regional Employment Statistics 1841-1971 (Cambridge University Press, 1979), pp 186-192, 210-216, 234-252

Appendix 4: Robustness Check Regression Tables

Table A6: Effect of 1908 Policy implementation on Aggregate Patent Quantity

	Coefficient	Std. err.	P-value
post_policy	0.90	0.11	0.41
_cons	5.83	0.07	<0.01
obs =	231.00		
F -statistic =	0.41		
R^2 =	0.00		

Notes: Significance levels are indicated as follows: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$
Source: Bergeaud, Antonin and Verluise Cyril. "PatentCity: A Dataset to Study the Location of Patents since the 19th Century." Harvard Dataverse, 2022. https://doi.org/doi:10.7910/DVN/PG6THV; C.H. Lee, British Regional Employment Statistics 1841-1971 (Cambridge University Press, 1979), pp 186-192, 210-216, 234-252

Table A7: Effect of 1908 Policy Implementation with Regional Interactions

	Coefficient	Std. err.	P-value
post_policy	0.24	0.62	0.70
1907post_policy#Region			
London	–	–	–
Southeast	0.19**	0.88	0.03
East Anglia	-0.12	0.88	0.18
Southwest	-0.04	0.88	0.68
West Midlands	0.10	0.88	0.26
East Midlands	0.12	0.88	0.19
Northwest	0.04	0.88	0.67
Yorkshire & Humb.	-0.10	0.88	0.28
Northeast	0.09	0.88	0.29
Wales	0.24***	0.88	<0.01
Scotland	0.07	0.88	0.44
obs =	231.00		
F -statistic =	332.94		
R^2 =	0.97		

Notes: Significance levels are indicated as follows: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$
Source: Bergeaud, Antonin and Verluise Cyril. "PatentCity: A Dataset to Study the Location of Patents since the 19th Century." Harvard Dataverse, 2022. https://doi.org/doi:10.7910/DVN/PG6THV; C.H. Lee, British Regional Employment Statistics 1841-1971 (Cambridge University Press, 1979), pp 186-192, 210-216, 234-252

Table A8: The Effect of the 1908 Policy Implementation on Quantity of Patents Sealed within each Region, with Industry Employment Controls

Southeast	**Coefficient**	**Std. err.**	**P-value**
Post_policy	-0.06	0.22	0.78
Industry Group 1	-77.21	105.03	0.48
Industry Group 2	14.16	15.58	0.38
Industry Group 3	68.01	85.99	0.44
Industry Group 4	-19.17	19.77	0.35
Industry Group 5	1.54	1.54	0.34
Industry Group 6	0.68*	0.35	0.08
obs =	21		
F -statistic =	0.008		
R^2 =	0.7119		

Wales	**Coefficient**	**Std. err.**	**P-value**
Post_policy	0.48	0.34	0.89
Industry Group 1	172.47	1263.40	0.89
Industry Group 2	15.58	1071.99	0.99
Industry Group 3	14.48	45.23	0.75
Industry Group 4	-54.31	683.03	0.94
Industry Group 5	-104.62	1239.09	0.93
Industry Group 6	-0.32	0.38	0.42
obs =	21		
F -statistic =	0.151		
R^2 =	0.505		

Notes: Significance levels are indicated as follows: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$
Source: Bergeaud, Antonin and Verluise Cyril. "PatentCity: A Dataset to Study the Location of Patents since the 19th Century." Harvard Dataverse, 2022. https://doi.org/doi:10.7910/DVN/PG6THV; C.H. Lee, British Regional Employment Statistics 1841-1971 (Cambridge University Press, 1979), pp 186-192, 210-216, 234-252