

**UNIVERSITY OF WAIKATO**

**Hamilton New Zealand**

**New Perspectives on Patenting Activity in New Zealand 1860-1899**

Matthew Gibbons and Les Oxley

**Department of Economics**

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*Corresponding Author*

**Matthew Gibbons**  
Economics Department  
Waikato Management School  
University of Waikato  
Private Bag 3105  
Hamilton  
NEW ZEALAND, 3216

Email: [mgibbons@students.waikato.ac.nz](mailto:mgibbons@students.waikato.ac.nz)

**Les Oxley**  
Economics Department  
Waikato Management School  
University of Waikato  
Private Bag 3105  
Hamilton  
NEW ZEALAND, 3216

Phone: +64 (0)7 838 4076

Email: [les.oxley@waikato.ac.nz](mailto:les.oxley@waikato.ac.nz)

## **Abstract**

Existing research suggests that New Zealand was, on a per capita basis, the wealthiest and most prolific patenting nation during the late nineteenth century. By quantifying lapsed applications, patent renewals, and expenditure on patent fees, rather than just patent applications, we consider the real level of innovative activity. Our results show that while reductions in patent fees and required advertising in the early 1880s led to a sharp increase in applications by people living in New Zealand, overseas patent applications and total expenditure on New Zealand patents showed relatively steady growth between 1860 and 1899. Lower fees succeeded in increasing patenting by skilled New Zealand trades workers (although engineers still dominated), however, patenting by unskilled workers, such as labourers, remained low. People living in New Zealand made over sixty per cent of patent applications, but overseas patentees paid over half of patent fees because relatively fewer of their applications lapsed or were not renewed. Although women made greater use of the patent system over time, even in 1899 they accounted for only 2.5 per cent of patent applications.

## **Keywords**

New Zealand patents

Granger causality

patent expenditure

## **JEL Classifications**

O31; N17; N37

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The role of technological change, inventiveness and innovation has a long and meticulous economic and historical tradition, typically illustrated with reference to the first and subsequent industrial revolutions, and often measured by simple patent counts data.<sup>1</sup> At the economic theory level, this technology-led route to economic growth has been reinvigorated by the development and popularity of endogenous (macro) economic growth models and the new economic geography.<sup>2</sup>

Inspired by the seminal work of Khan and Sokoloff, many economic historians have followed a ‘who were the patentees,’ approach to analyse the incentives for inventors to invent, which when linked to country-specific institutional differences and reforms in the patenting process, has led to a more ‘micro-economic’ focus on inventiveness. An important tenet of the Khan and Sokoloff approach, also considered by Bottomley, is the extent to which ‘inventive activity responded to market conditions’, or more generally the degree to which ‘inventors were responding to expected profits’.<sup>3</sup> The incentives for inventors to undertake inventive activity and the propensity to patent depends on the institutional framework in which the inventor works because fees affect the cost and level of patenting.<sup>4</sup>

In Britain, Nicholas found that the 1884 reduction in initial patent fees increased patent applications by a factor of two and a half, with more inventive activity moving within the patent system. Nevertheless, his sample showed that the geographic location of patentees, the proportion of patents by corporates, the industry sectors patented, and the proportion of full term patents were similar. The number of citations to English inventor patents in the United States also showed little change, implying innovation had not increased.<sup>5</sup> Using a larger dataset of all patent applications by British inventors between 1879 and 1888, however, Kuegler illustrated the changes that occurred. She found high-quality patenting increased and that there was more patenting by inventors from less wealthy backgrounds.<sup>6</sup> Data for Australia shows a large jump in patenting in Victoria following the ‘massive reduction’ in patent fees from 1885, although this effect was much larger for patentees living in Victoria than for those living elsewhere.<sup>7</sup> However, changes in the number of lapsed patents were not considered. Summary data on lapsed patents in Australian patent systems before Federation is available,<sup>8</sup> but has not been systematically analysed and evaluated.

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<sup>1</sup> Greasley and Oxley, 'Causality and the first industrial revolution'; Sullivan, 'England's "Age of invention"'; Sullivan, 'The revolution of ideas'; MacLeod, *Inventing the industrial revolution*; Lamoreaux and Sokoloff, 'Inventors, firms and the market for technology'.

<sup>2</sup> Some important contributions are summarized in Galor and Weil, 'Population, technology, and growth'.

<sup>3</sup> Khan and Sokoloff, 'Schemes of practical utility'; Bottomley, 'Patenting in England, Scotland and Ireland' .

<sup>4</sup> MacLeod, 'Patents for invention'; Khan and Sokoloff, 'Patent institutions, industrial organization'.

<sup>5</sup> Nicholas, 'Cheaper patents', pp.326, 334, 337.

<sup>6</sup> Kuegler, 'The responsiveness of inventing', pp. 2, 14, 21.

<sup>7</sup> Magee, *Knowledge generation*, pp.18, 35, 96-99.

<sup>8</sup> Easthope, *Australian colonial patents*.

Macro-level explanations, and use of (macro-level) data (e.g., GDP and total patent counts), reside alongside some of these more disaggregate approaches, where the typical type of analysis found in this (macro) branch of the literature tends to be time-series tests of correlation or causality.<sup>9</sup> There has also been growing interest in determining which patents are most important, with common approaches including weighting patents by variables such as citations, expenditure, renewals, overseas registration, or the reputation of inventors.<sup>10</sup>

In this paper we focus upon New Zealand, which previous research has suggested was a ‘precocious country of inventors’ – one where in 1900 per capita patenting exceeded that of Australia and in fact ‘led the world’, while New Zealand was also one of the wealthiest countries in the world.<sup>11</sup> This co-leadership position (per capita wealth and per capita patent applications) of New Zealand seems to embody the expected characteristics of both the endogenous growth and new economic geography models of economic growth and hence, is deserving of additional, careful and deeper analysis than has previously been undertaken.

Although a time series is not available, New Zealand patent applications in London exceeded those from any other British colony and possession except Victoria, Canada, and India, and most foreign states.<sup>12</sup> Furthermore, patent applications usually led economic output,<sup>13</sup> while agglomeration effects and knowledge spillovers associated with patenting occurred.<sup>14</sup> However, the emphasis and conclusions of these studies focused on *macro-economic* relationships rather than the Khan-Sokoloff-Bottomley approach of, ‘what incentives (to patent) did inventors face and did they follow them’? In addition, these studies did not include expenditure on patents, while the summary data used contained little information on the demographic characteristics of patentees.

In the new research presented here, prior notions about the state of New Zealand inventiveness between 1860 and 1899 are tested using unit record data on 12,283 patent applications that records lapsed applications and renewals, and expenditure on fees for each patent. We consider some new views, including the possible ‘openness-of-opportunity’ of New Zealand’s patent system to inventors from different backgrounds in the mid to late 19<sup>th</sup>

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<sup>9</sup> Greasley and Oxley, 'Patenting, intellectual property rights'. There is also another extensive and important literature on innovation and growth which focuses on non-patented innovations and the role of secrecy and guilds (see Moser, ‘Patent laws’) and also the role of prizes (see Burstein and Murray, ‘Innovation prizes’) but this goes beyond the scope of this article.

<sup>10</sup> Nuvolari and Tartari, 'Bennet Woodcroft and the value of English patents', pp. 98, 105; Sullivan, 'Estimates of the value'; Streb, Baten, and Yin, 'Technological and geographical knowledge', p.354.

<sup>11</sup> Greasley and Oxley, 'Knowledge, natural resource abundance', p. 450; Williams and Oxley, 'Geography of inventiveness', pp. 155-156.

<sup>12</sup> Registrar Patents Office, (AJHR, H-1 1890), p. 3.

<sup>13</sup> Greasley and Oxley, 'Knowledge, natural resource abundance', p. 454.

<sup>14</sup> Williams and Oxley, 'Geography of inventiveness', p. 169.

century. In particular, were high per capita patenting rates associated with high patenting by a wide range of economic and social groups?

In Section I we outline New Zealand patent legislation from 1860 to provide and locate some *a priori* dates of interest, while in Section II we calculate the estimated inflation adjusted cost of patenting in New Zealand between 1860 and 1899. In Section III we consider changes in the total number of applications and of the effect of variations in the proportion of lapsed and renewed patents on investment in patents. Then in section IV we utilize the new patent expenditure data to test the extent to which the changing cost of patenting explains (Granger-caused) actual patenting activities in New Zealand over this 40-year period. In section V the occupations of patentees are discussed and compared to equivalent data for the self-governing colony of Victoria, and uniquely also to 1886 Census data for New Zealand males. Reductions in initial application fees during the early 1880s sought to make patenting accessible to a wider range of occupational groups, and the extent to which this succeeded is systematically evaluated. Furthermore, in Section VI patenting by women and by New Zealand's indigenous Maori population is quantified to investigate the extent to which these groups made use of the patent system. Section VII concludes.

## I

Patents are frequently justified on the basis that they ensure innovation and invention are fairly rewarded and protected. In addition, patents provide incentives for inventors by potentially creating temporary monopoly profits. Although counter arguments exist,<sup>15</sup> patents are typically assumed to stimulate economic growth by ensuring that in exchange for a temporary monopoly, knowledge and inventions are written down and on expiry of the patent become available to others.<sup>16</sup>

New Zealand's 1860 Patents Act was similar to legislation in Britain and in the British colony of Victoria in Australia. Applicants paid ten pounds for a fourteen-year term, and were required to advertise applications in the *Government Gazette* and in provincial newspapers. Patentees could also pay ten pounds for a letter of registration that extended overseas patent protection to New Zealand.<sup>17</sup> Under the more detailed Patents Act 1870, two pounds 10 shillings was due on depositing the specification, and the same fee charged for obtaining letters patent, while an extension before the end of the third year cost 15 pounds.<sup>18</sup> Fees were now lower for the initial application to allow inventors to test whether they could

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<sup>15</sup> Boldrin, Levine, and Nuvolari, 'Do patents encourage or hinder innovation?'

<sup>16</sup> Auger, *Information sources on patents*, p. 10; Dutton, *Patent system*, pp.17-22.

<sup>17</sup> New Zealand Government, 'Patents Act 1860'.

<sup>18</sup> New Zealand Government, 'Patents Act 1870', p. 402.

get a return on their invention, but higher for a 14-year term.<sup>19</sup> In addition, advertising costs doubled because two insertions of applications were required.

During the 1870s, there was concern that application fees dissuaded ‘intelligent artisans’ from patenting.<sup>20</sup> The Patents Amendment Act of 1879 slightly reduced the fee for obtaining a patent, halved advertising costs by only requiring one insertion in newspapers, and reduced the renewal fee to 10 pounds.<sup>21</sup> An 1881 amendment reduced the cost from 14 to 10 pounds for acquiring a patent and renewing it to full term, with the application fee halved to a pound. In addition, newspaper advertising of patent applications was no longer required.<sup>22</sup> A further amendment in September 1882 halved the cost of an application, for the second time in less than a year, to 10 shillings.<sup>23</sup> The 1889 Act then reversed the shift to lower fees, with renewal fees for a 14-year patent increasing from 7 to 15 pounds from 1890.<sup>24</sup>

**Table 1: Nominal Cost of Applying For and Renewing a Patent**

Act	1860	1870	1879	1881	1882	1883	1889
Into force	1861	1871	1880	1882	Sept 82	1884	1890
On depositing specification	£10.0	£2/10	£2.00	£1.00	£0/10	£0/10	£0/10
On depositing revised specification						£0/10	£0/10*
On obtaining letters patent		£2/10	£2.00	£2.00	£2.00	£2.00	£2.00
Extending patent before 3 <sup>rd</sup> year		£15.0	£10.0				
Extending patent before 4 <sup>th</sup> year							£5.00
Extending patent before 5 <sup>th</sup> year				£7.00	£7.00	£7.00	
Extending patent before 7 <sup>th</sup> year							£10.00
Cost of taking to 14 years nominal	£10.0	£20.0	£14.0	£10.0	£9.5	£9.5 or £10.0	£17.5 or £18
Cost of taking to 14 years 1861 values ( <u>as decimal</u> )	£10.0	£24.1	£20.25	£14.8	£14.2	£14.9 or £15.6	£29.0 or £29.9
Deposit for challenging	£10.0	£2/10	£2	£2	£2	£2	10s
Cost of revising	£10.0	£2/10	£2/10	£2/10	£2/10	£2/10	£1
Letters of registration	£10.0	£10.0	£10.0	£10.0	£10.0	£10.0	-

\* Providing lodged provisional specification in first instance. If filed complete specification initially the cost of amending the specification was £1.00.

Sources: New Zealand Government, *Patents Act 1860*, *Patents Act 1870*, *Patents Amendment Act 1879*, *Patents Amendment Act 1881*, *Patents Amendment Act 1883*, *Patents Designs and Trade-Marks Act 1890*.

<sup>19</sup> *New Zealand Parliamentary Debates*, 21 June 1870, p.31.

<sup>20</sup> *New Zealand Parliamentary Debates*, 4 Nov. 1879, p 66.

<sup>21</sup> New Zealand Government, 'Patents Amendment Act 1879'.

<sup>22</sup> New Zealand Government, 'Patents Act Amendment Act 1881'.

<sup>23</sup> 'Changes in the patent law' in *New Zealand Herald*, 26 Sept. 1882. There were 20 shillings in a pound and 12 pence in a shilling, and therefore 240 pence in a pound.

<sup>24</sup> 'Editorial' in *New Zealand Herald*, 24 Oct. 1889; New Zealand Government, 'Patents, Designs and Trade-Marks Act, 1889,' p.59.

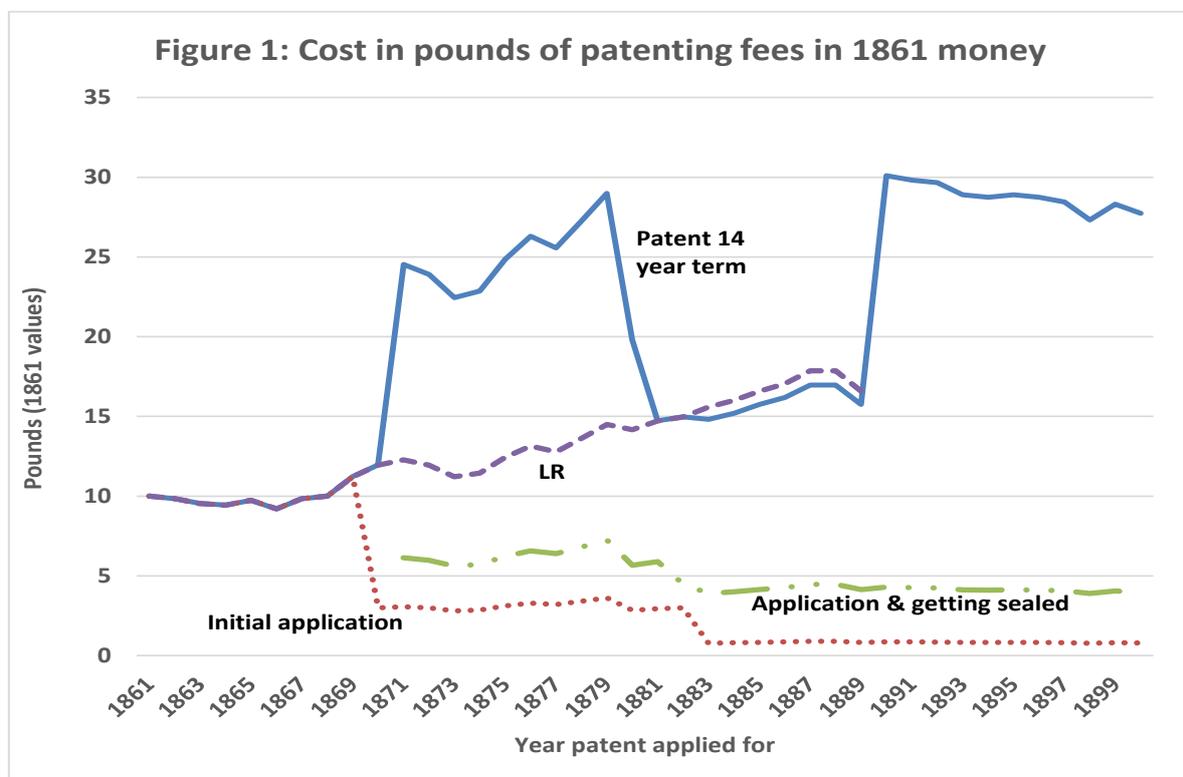
**Table 2: The Duration of a Patent**

Act	1860	1870	1883	1889
On application	4 months	6 months	12 months	12 months
Initial term	14 years	3 years	5 years	4 years
2 <sup>nd</sup> term				3 years
Maximum duration after sealing	14 years	14 years	14 years	14 years, but could ask for a further extension

Source: As for Table 1.

II

We now consider the inflation-adjusted cost of patenting. The best available data suggests that consumer prices in New Zealand fell by 40 per cent between the late 1860s and the early 1870s,<sup>25</sup> before slightly increasing thereafter. Figure 1 shows that total government fees for patenting an invention for 14 years fluctuated only slightly in the 1860s, before increasing sharply in 1871 and becoming considerably greater than the cost of a letter of registration. However, Table 1 shows that the initial cost of patent fees for obtaining a patent fell from 1871, even though the cost of a 14-year term increased substantially. The real total cost of taking a patent to 14 years trended upwards, before sharply falling due to lower fees in 1880 and in 1882. A sharp increase in fees for a 14-year term in 1890 ensured the cost thereafter remained in excess of 25 pounds.



Source: As for Table 1; Briggs, *Looking at the Numbers*.

<sup>25</sup> Briggs, *Looking at the numbers*.

From 1871 the combined legislated cost of an initial application and of getting a patent sealed was much lower than for patenting for a 14-year term. However, under the 1860 Act there was provision for fee refunds, less administration expenses, to unsuccessful applicants.<sup>26</sup> Unsuccessful patent applications in the 1860s were therefore attributed two and a half pounds in fees. The cost of an initial application fell from almost two pounds in 1860 values in 1871 to half a pound (10 shillings) for complete specifications for a patent filed in the 1890s. The cost of getting a patent sealed remained stable in nominal terms from 1882 at two pounds. In 1893, general labourers earned on average just over two pounds per week,<sup>27</sup> making sealing a patent a significant cost.

The cost of advertising an application in newspapers significantly added to the cost of a patent. In 1879, the estimated cost of required advertising for a patent application was 11 to 12 pounds.<sup>28</sup> An inventor's detailed accounts (see Table 3) put the 1881 cost of a sealed patent at over 16 pounds, even though the patentee had saved two pounds by preparing their own drawings.<sup>29</sup> To place these costs in context, at this time a cow cost three to seven pounds, a saddle horse about 12 pounds, and a draught horse about 20 to 30 pounds.<sup>30</sup>

**Table 3: Estimated Total Costs of Taking Out a Patent in 1881 before the Elimination of Advertising Requirements**

Expenses	Cost in Pounds, Shillings and Pence
Dunedin agent	5/0/0
Wellington agent	1/1/0
Telegrams and postage	0/4/2
Advertising once in 10 newspapers	5/4/0
Cost of application and sealing patent	4/0/0
Miscellaneous expenses	0/3/0
Preparing specification and parchment	0/10/0
<b>Total</b>	<b>16/8/8</b>

Source: 'The patents act' in *Otago Daily Times*, 14 Jan. 1882.

A newspaper reported that the opening of local patent offices would save applicants agency fees of five pounds.<sup>31</sup> However, a patent agent argued the savings were an illusion since inventors would still need specialist help with checking specifications. He stated two pounds five shillings would be a standard charge for these services.<sup>32</sup> An 1886 estimate was two and a half pounds, although the agent commented that some patentees were seeking

<sup>26</sup> New Zealand Government, 'Patents Act 1860', p.97.

<sup>27</sup> Greasley and Oxley, 'Globalization and real wages', p. 31.

<sup>28</sup> 'The patent laws' in *Evening Post*, 22 Sept. 1879.

<sup>29</sup> 'The patents act' in *Otago Daily Times*, 14 Jan. 1882.

<sup>30</sup> *Statistics of the colony of New Zealand* (1884), pp.186-187.

<sup>31</sup> 'Among the bills' in *Otago Daily Times*, 7 Oct. 1882.

<sup>32</sup> 'The patent law' in *Otago Daily Times*, 2 Nov. 1882.

publicity for products by filing provisional applications that would not survive legal scrutiny.<sup>33</sup> Another agent implied that four pounds ten shillings should be budgeted for agent fees for getting a patent sealed.<sup>34</sup> The leading patent agency firm stated in 1899 that it paid on behalf of its clients two-thirds of patent fees,<sup>35</sup> indicating most patentees were paying an agent.

Reported newspaper advertising costs were approximately 11 pounds in the late 1870s when two insertions were required, and about half that amount from 1880 until advertising requirements ceased in September 1881. Only one insertion was required for patents up to 1871, which halved the real cost. All applications advertised in newspapers were attributed these amounts, after adjusting for inflation. Until the requirement for applications to be on parchment ended in 1884 this cost was attributed, and the sixpence cost of the standard form was attributed thereafter. Reported agency costs vary, and no details are available on fees charged by Henry Hughes, which became the biggest patent agency in the 1890s. Since there is no information available on which applications included drawings between 1874 and 1891, agent fees and drawing costs have not been attributed.

Figure 2 shows the calculated fees and advertising costs of taking out a 14-year patent in 1861 values. Compulsory newspaper advertising and parchment costs were almost as expensive as government fees until the early 1880s. The total cost of a 14-year patent increased sharply after 1870, before declining in the early 1880s. Increased government fees from 1890 then increased the total cost of a 14-year patent to about 30 pounds, which was about 10 pounds higher than in the 1860s.

### III

Figure 3 shows patent applications per 10,000 people living in New Zealand. Even after allowing for population increases, patent applications clearly increased sharply from the early 1880s, particularly by people living in New Zealand, as lower patent fees and advertising requirements came into effect. Similar increases in patent applications occurred during the early 1880s in Britain and in Victoria after application fee reductions.<sup>36</sup> The increase in per capita New Zealand patent applications from overseas inventors slightly precedes the 1880 reduction in application fees. Between 1860 and 1899, 62.3 per cent of patent applications were by people living in New Zealand. Overseas patent applications were largely from people living in modern day Australia (16.4 per cent of the total), Britain (11.1 per cent) and the United States (6.0 per cent) with Germany the highest non-English speaking country at just one per cent of applications.

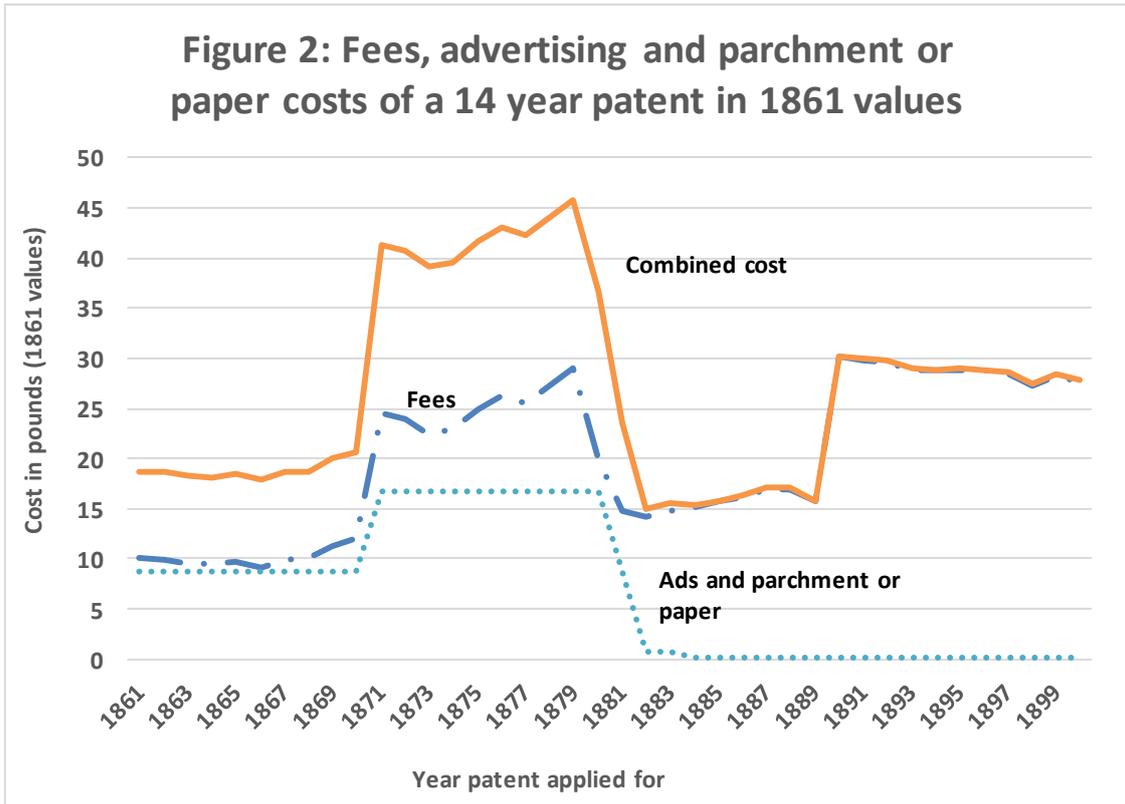
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<sup>33</sup> 'The cost of patents' in *Evening Post*, 24 Mar. 1886.

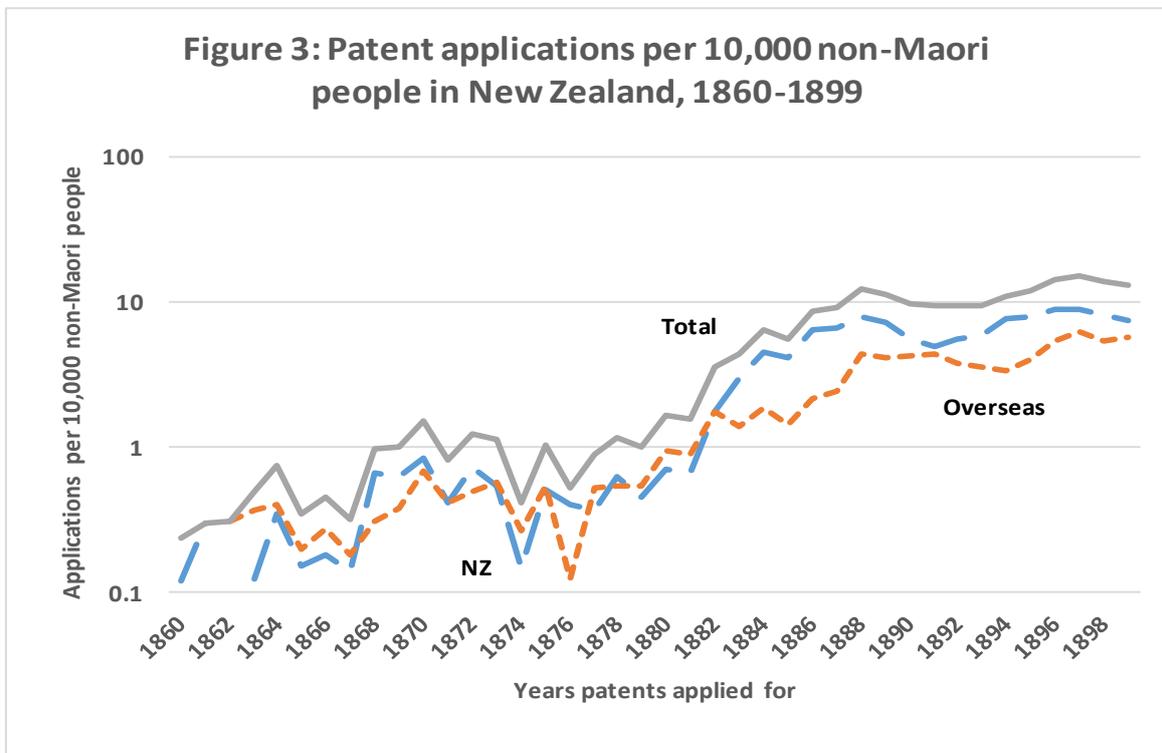
<sup>34</sup> Murdoch, How to make money by patents.

<sup>35</sup> 'The law of patents' in *Press*, 27 Jan. 1899.

<sup>36</sup> MacLeod *et al.* 'Evaluating inventive activity', pp. 555-557; Magee, *Knowledge generation*, pp.17, 96.

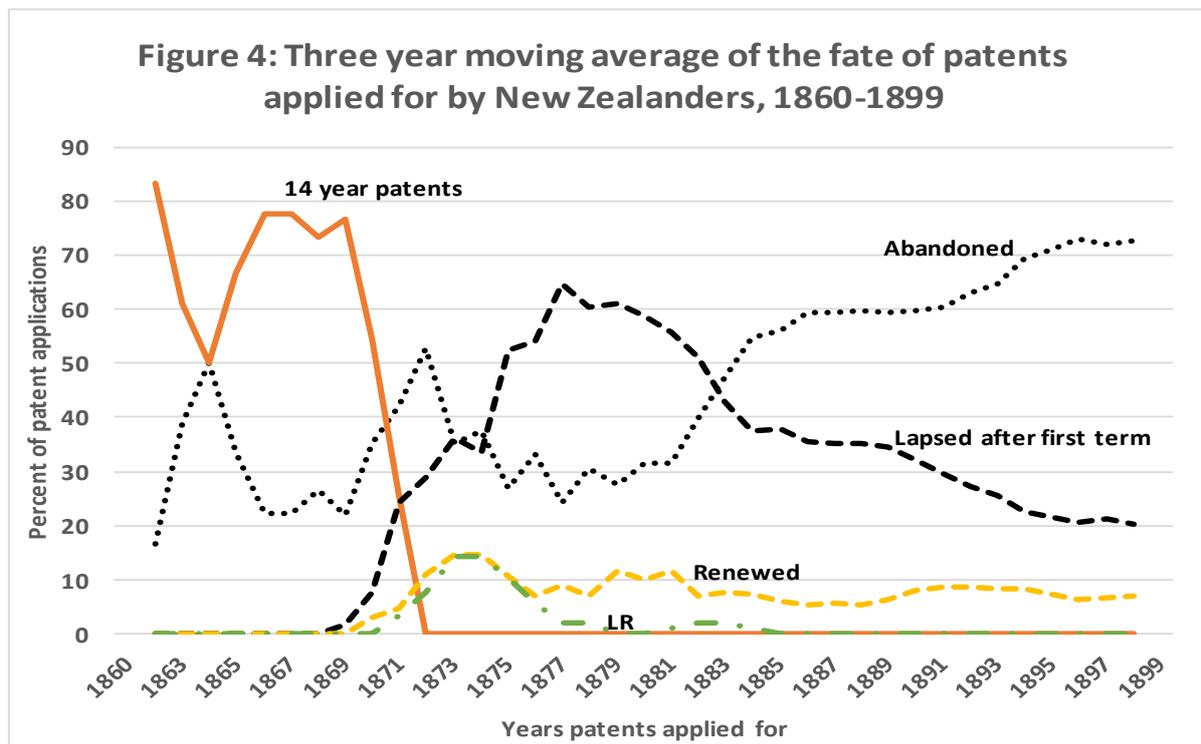


Source: As for Figure 1 and Table 3.



Sources: Unit record data from: Patent Office, *Specifications of Inventions* (1874-1879); *New Zealand Gazette* (1860-1899); Registrar Patent Office, *Annual Report* (1880-1890); Patent Office, *Register of Patents* (1860-1899). Population data from New Zealand Government, *Statistics of the Colony of New Zealand*.

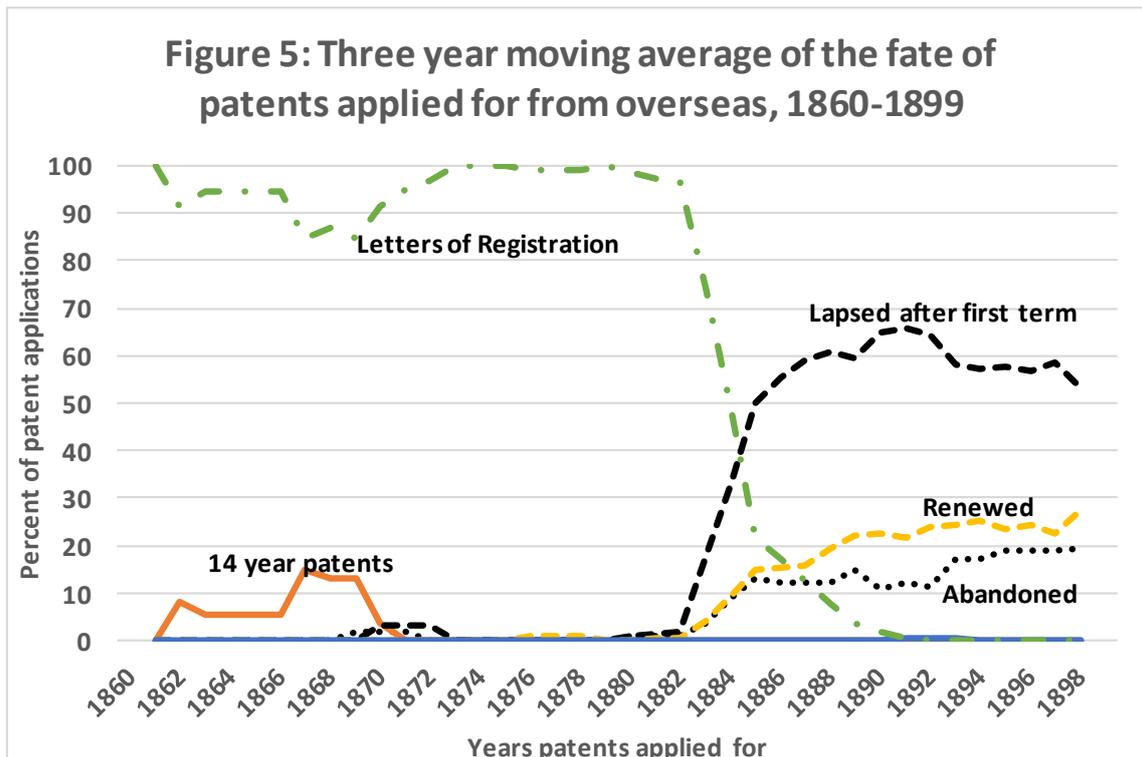
While the number of patent applications per capita increased over time, Figure 4 shows that the proportion of patent applications by New Zealanders that went full term declined sharply. In the 1860s, most patent applications by New Zealand inventors were successful, and therefore ran for a 14-year term. However, some applications were abandoned or unsuccessful. Changes to patent laws and fees resulted in many 1870s patent applications lapsing after their first term, with usually less than ten per cent renewed. The proportion of abandoned patents increased after the cost of patenting fell in the early 1880s, and from 1883 consistently more than half of patent applications by New Zealanders were abandoned.



Source: As for Figure 3.

Figure 5 shows that during the 1860s and 1870s most overseas patent applicants opted for letters of registration. Lower initial patent fees during the 1880s resulted in increased use of letters patent by overseas inventors, with most of these applications lapsing after the first term. However, some overseas inventors continued to use letters of registration, despite their cost advantage ending in 1882, until provision for them ceased in 1890. Overseas inventors consistently abandoned less than twenty per cent of their New Zealand patent applications, with those who applied for a patent in the small New Zealand market usually also paying to have their application sealed.

There was also an increase in abandoned patents in Britain after a reduction in application fees took effect in 1884,<sup>37</sup> and average unsealed patent applications in Britain in the 1880s and 1890s were similar to the per cent abandoned in New Zealand.<sup>38</sup> Similarly, after patent application fees reductions in Victoria in 1884, during the early 1890s the abandonment rate for patent applications was about 40 per cent.<sup>39</sup> In his analysis of patenting in Victoria Magee admits that not controlling for changes in the abandonment rate, apart from including a dummy variable in regression analysis for the 1884 change in patent fees, is a limitation.<sup>40</sup>



Source: As for Figure 3.

Since the cost of applying for a patent dramatically fell over time, and the average duration of a patent decreased, total expenditure on patents is potentially a better measure of the resources invested in invention than the number of patent applications.<sup>41</sup> Patent quality in other countries has been calculated using citation data,<sup>42</sup> but information on citations is not available for New Zealand during this period. Figure 6 shows that our calculation of patent fees expenditure follows a similar trend to the available official data. The match is imperfect, partly because the calculated fees are on a calendar basis whereas the official expenditure

<sup>37</sup> MacLeod et al., 'Evaluating inventive activity', pp. 556-558.

<sup>38</sup> Boehm, *The British patent system*, pp. 33-34.

<sup>39</sup> *Statistical Register of the Colony of Victoria for the Year 1893: VII Production*, p. 70.

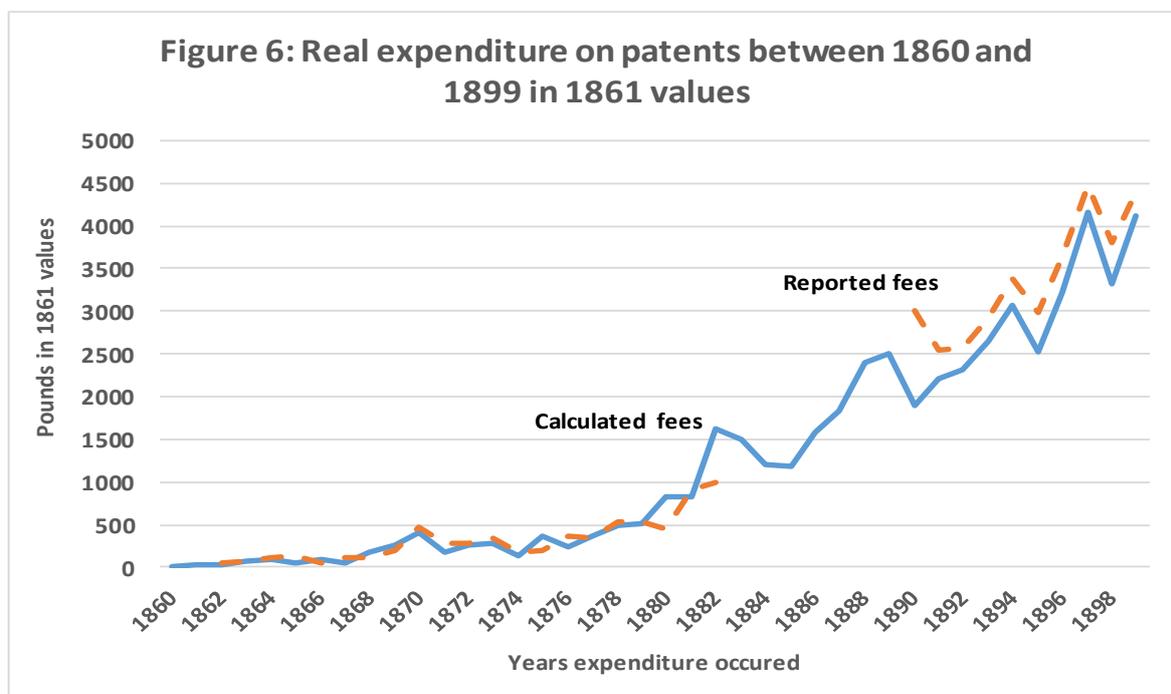
<sup>40</sup> Magee, *Knowledge generation*, pp. 7-9.

<sup>41</sup> Schankerman and Pakes, 'Estimates of the value'; Sullivan, 'Estimates of the value', pp. 37-38.

<sup>42</sup> Nuvolari, 'Collective invention', pp. 97-98.

data is for financial years until 1883. In addition, the fee charged for unsuccessful patent applications was estimated up to 1871 since officials made decisions about partial refunds on a case-by-case basis. The official data also includes other fees, such as assignment fees, and unit record data on these fees is only available from 1890<sup>43</sup> and therefore not included here. Nevertheless, the similarity of the results is reassuring.

Results from the calculated data shows that real expenditure on patent fees reached 100 pounds for the first time in 1868, and 412 pounds by 1870. Lower initial fees for patent applications then reduced expenditure on patenting until the late 1870s. The reduced application and renewal fees introduced in 1880 and 1882 were associated with expenditure on total patent fees spiking at 1,630 pounds in 1882. Further reductions in fees initially reduced patent fees expenditure, but in 1889 expenditure reached a new peak of 2,495 pounds. Higher renewal fees were then associated with lower patent fees expenditure in 1890 and 1891. Thereafter patent fees expenditure grew again, peaking at 4,159 pounds in 1897.

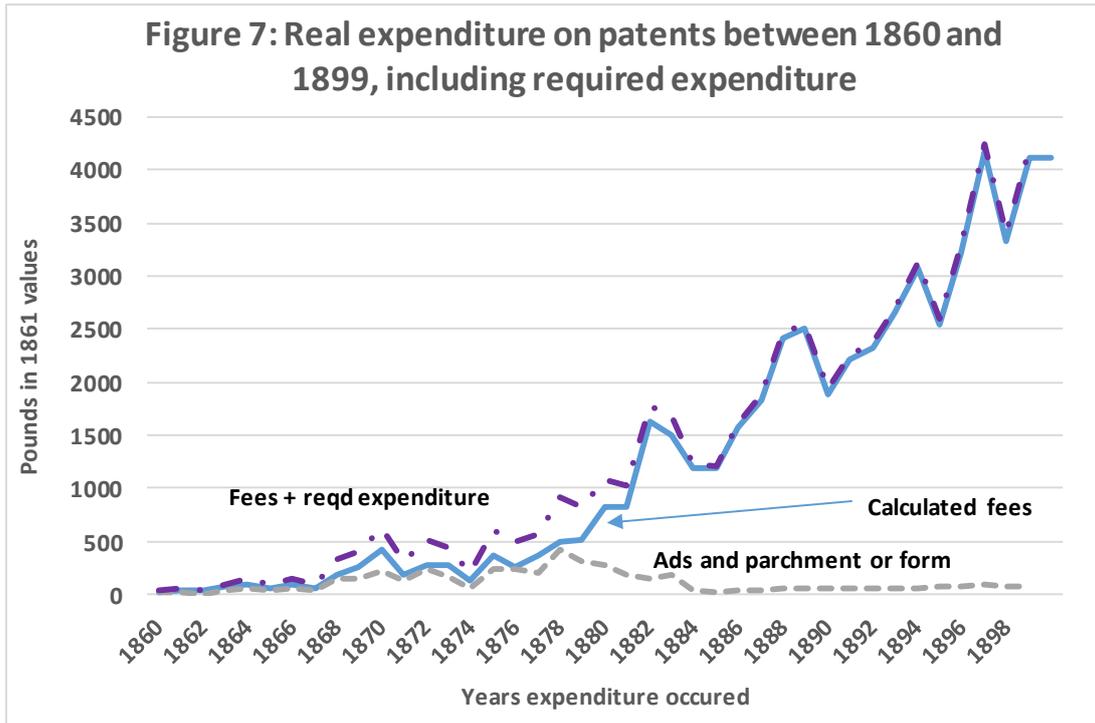


Sources: As for Figure 1 and Figure 3; New Zealand Government, *Finance Accounts* (AJHR, B1, 1863-1882); Registrar Patent Office, (AJHR, 1890-1900).

Figure 7 shows real expenditure on patents after including costs for advertising and for parchment or the standard form used from 1884. In the 1870s these costs sometimes almost doubled expenditure. Nevertheless, patenting fees and required expenditure was only equivalent to 0.08 per cent of private Gross Fixed Capital Formation in 1899.<sup>44</sup>

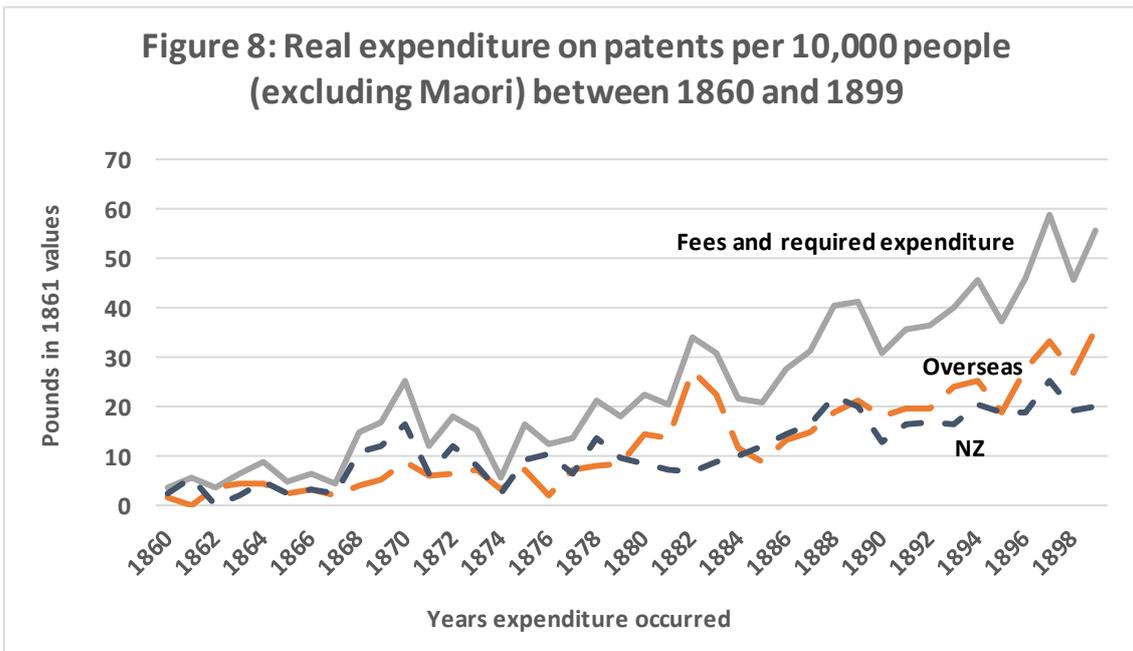
<sup>43</sup> 'Supplement to the New Zealand Gazette' (1891), pp. 1081-1082.

<sup>44</sup> Dowie, 'The course and character of capital formation', p.54.



Source: As for Figures 1 and 4.

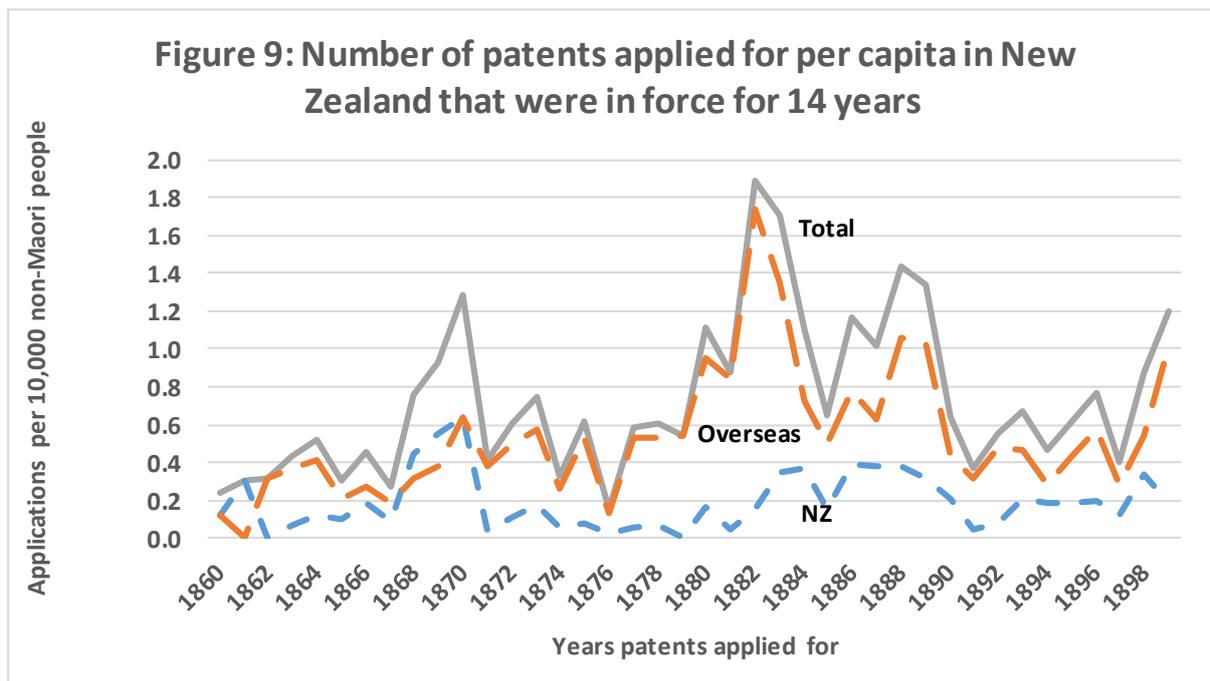
Figure 8 shows that even after allowing for population growth, total real expenditure on patents increased considerably, but more slowly than applications. Inventions by New Zealanders accounted for 62 per cent of applications, but just 45 per cent of fees and other required expenditure on patents, indicating that just counting patent applications is potentially a poor way of measuring the sources of knowledge in the New Zealand economy.



Source: As for Figures 1 and 3.

Figure 9 shows that 14-year patents, which are sometimes used as an indicator of the quality of a patent,<sup>45</sup> were usually applied for by overseas inventors.<sup>46</sup> The increase in 14-year patent fees from 1871 was associated with a decrease in the number of 14-year patents per capita by New Zealanders. This followed a spike in patents relating to the flax industry, and inventors protecting intellectual property for 14 years before this became more costly. The reduction in patent fees in the early 1880s coincided with an increase in the number of 14-year patents. However, most of this increase was due to more overseas patentees applying for letters of registration in New Zealand, and the cost of these had not changed. The increase in letters of registration reflected greater protection of vehicle and manufacturing inventions from overseas, with the 1882 spike largely driven by high heat, light, and power patent registrations. The reduction in patent application fees during the early 1880s also coincided with a modest increase in the number of 14-year patents by New Zealanders.

Higher costs for a 14-year patent from 1890 and the end of letters of registration occurred at the same time as a sharp decline in overseas 14-year patent applications. Patent applications by New Zealanders for patents that ran for 14 years were declining during the late 1880s before the renewal cost increased from 1890.



Source: As for Figure 3.

<sup>45</sup> Nicholas, 'Cheaper patents', p. 326; Streb, Baten, and Yin, 'Technological and geographical', p. 352.

<sup>46</sup> Letters of registration have been treated as 14-year patents here, although if there was a delay in applying for protection in New Zealand they may sometimes have run for a shorter period.

#### IV

Researchers have identified patent costs as a key factor affecting the level of patenting,<sup>47</sup> and this is now empirically tested for New Zealand. Table 4 presents the results of time series tests of the order of integration of relevant series both under the assumption of no breaks (in the series) and for allowing breaks (where the timing of breaks is identified).<sup>48</sup> Figures 10-15 graph the logs of six of the main variables, with truncation of the axes sometimes exaggerating changes,<sup>49</sup> while graphs for the other four series are in online appendix S1.

When tests for potential structural changes in the data are considered, the automatically chosen break date for combined application fees and required newspaper costs is 1881, and Figure 14 visually confirms this. For applications per capita by New Zealanders (Figure 11), the break date was 1883. Changes in total applications in Figure 10 are more complex, partly because changes in fees occurred at different times for New Zealand and overseas applicants. Both the cost of getting a patent sealed (Figure 15) and of the total cost of a 14-year patent (online appendix S1) had multiple breakpoints.

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<sup>47</sup> Khan, *The democratization of invention*, p. 7; MacLeod *et al.* 'Evaluating inventive activity', pp. 555-556; Magee, *Knowledge generation*, p.99.

<sup>48</sup> Certain time series-based tests are potentially biased in the face of breaks in the data series for example; the Augmented Dickey-Fuller (ADF) statistics are biased towards non-rejection of a unit root. See Greasley and Oxley, 'Cliometrics' .

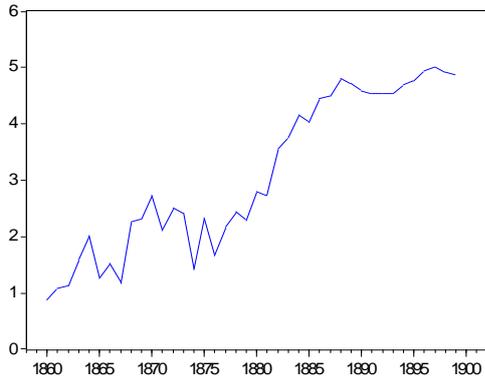
<sup>49</sup> Eviews v9 was used for all estimation and testing.

**Table 4: Unit Root Test Results using Modified Hannan-Quinn Criterion**

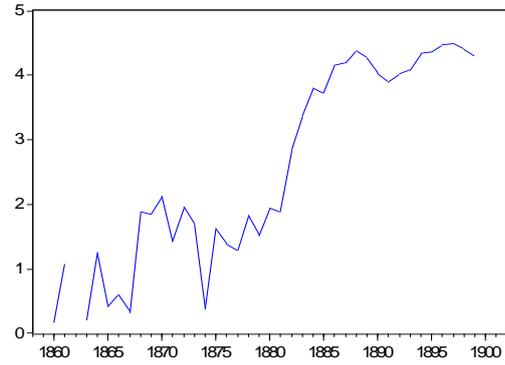
Variable (in logs)	Without a break					With a break				
	Integrated	Lags	Equation	ADF	P-value	Integrated, Break	Lags	Trend Specification	ADF	P-value
Applications per capita	I(1)	9	I	-3.32	0.02	I(1), 1878	9	I	-11.75	<0.01
Applications by NZers per capita	I(1)	9	I	-3.59	0.01	I(0), 1883	9	T, I; break I	-4.87	<0.05
14 year patents per capita	I(1)	9	I	-9.72	0	I(1), 1891	9	I; break I	-10.13	<0.01
14 year patents by NZers per capita	I(1)	9	I	-7.92	0	I(1), 1891	9	I; break I	-8.34	<0.01
Initial fees cost	I(1)	9	I	-6.58	0	I(0), 1882	9	T,I; break T,I	-5.25	0.04
Ads & parchment/form	I(2)	9	I	-13.98	0	I(0), 1881	9	T, I; break I	-8.53	<0.01
Initial fees, ads & form	I(2)	9	I	-4.06	0	I(0), 1881	9	I, break I	-20.89	<0.01
Cost of sealing	I(1)	7	T,I	-5.94	0	I(1), 1889	7	I, break I	-6.07	<0.01
Total cost 14 years	I(1)	9	T,I	-3.67	0	I(1), 1882	9	I, break I	-5.57	0.02
Cost letter registration	I(1)	7	T,I	-4.00	0.02	I(1), 1873	7	I, break I	-4.53	0.04

I=intercept, T=trend

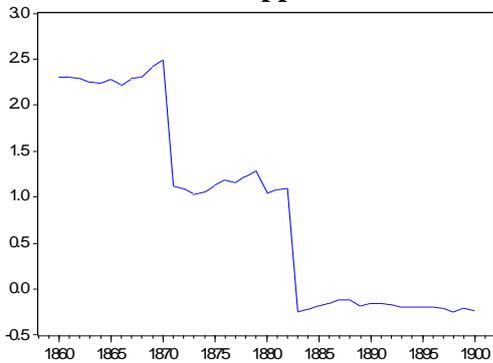
**Figure 10: Log of Total Applications per 100,000 People (excluding Maori)**



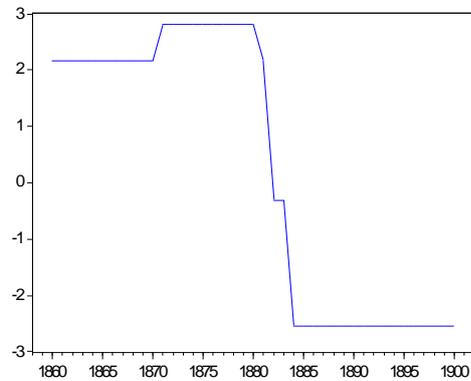
**Figure 11: Log of Applications by People Living in New Zealand per 100,000 Population (excluding Maori)**



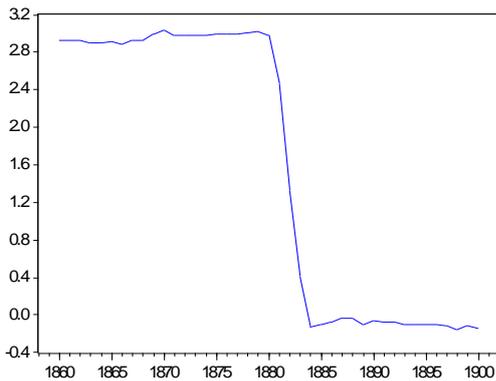
**Figure 12: Log of Fees Cost of Initial Application**



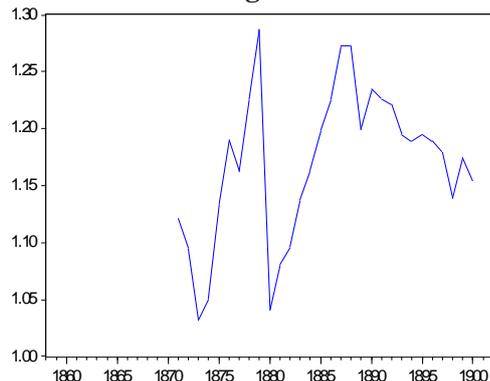
**Figure 13: Log of Cost of Newspaper Ads and Parchment or Form**



**Figure 14: Log of Total Cost of Application Fees and Ads and Parchment or Form**



**Figure 15: Log of Cost of Sealing a Patent**



Sources: As for Figures 1, 2 and 3.

The results of the univariate tests in Table 4 inform the Granger-type tests of causality shown in Table 5 below. Granger causality tests how much of the current value of a variable can be explained by its past values, and then tests whether adding lagged values of another variable improves the explanation. Appropriate tests of Granger-type causality depend

crucially on the data's order of integration.<sup>50</sup> However, if the series tested are I(0), standard F and  $\chi^2$  tests can be applied to the these levels data; if I(1) and cointegrated or I(1) and not cointegrated, other forms of the tests need to be applied.

Table 5 presents pair-wise Granger causality results for the variables, where a significant break point unit root test indicated that the data were I(0), and indicates that significant causality exists between the total cost of an application, including advertisements, and applications per capita by New Zealanders. There also appears to be Granger causality between total application costs and both fees costs and advertising costs. However, the total cost of an initial application, including advertising and parchment costs, Granger causes applications, rather than just the initial required fees, even though advertising costs could be avoided by quickly letting an application lapse.

**Table 5: Pairwise Granger Causality Probabilities  
between the Log of Variables Relating to New Zealand Applications**  
(Two Year Lag and using F-statistics)

	Dependent Variable p-values			
	Applications per capita by NZers	Application fees cost (no refund)	Advertising and parchment	Total cost application including ads
Applications p.c. by NZers	-	0.0739	0.5473	0.1926
Application fee costs	0.5477	-	<b>0.0049</b>	0.3297
Ads and parchment	0.1489	<b>0.0059</b>	-	0.5173
Total cost application including ads	<b>0.0177</b>	<b>0.0042</b>	<b>0.0000</b>	-

Values in bold are significant at a 5% level

Increased required newspaper advertising costs in 1871 almost exactly negated the effect of the 1871 reduction in application fees. As a result, a single steep reduction in the early 1880s dominates the changes in total costs for applying for and advertising a patent (Figure 14). Total initial costs, including advertisements, is therefore the cost variable best modelled as I(0).

Regressing the log of total applications by New Zealanders per capita on the log of the total cost of fees and advertising costs explained 88 per cent of the variance in patent applications by New Zealanders. The residuals show that applications before 1868 were lower than expected, suggesting some omitted variable bias (see online appendix S2).<sup>51</sup> For instance, New Zealand's low population may have meant that patent agent fees were higher in real terms in the 1860s than in later years.

<sup>50</sup> These are discussed in more detail in *ibid*.

<sup>51</sup> This is not surprising given the equation has not been constructed to maximize fit, but to consider a specific hypothesis.

**Table 6: Using OLS to Explain New Zealand Patent Applications per 100,000 People**

Dependent	Model 1	Model 2
Ln NZ patents per 100,000 people		
Constant	4.07 (0.08)***	2.49 (0.34)***
Ln fees, ads and form cost	-0.95 (0.08)***	-0.65 (0.07)***
Trend	-	0.05 (0.01)***
Dummy 1869-71	-	0.79 (0.17)***
AR(1)	-	-0.26 (0.13)*
Adjusted R <sup>2</sup>	0.88	0.93
Prob. Chi-Square(2)	0.06	0.25

\*=significant at a 10% level, \*\*=significant at a 5% level, \*\*\*=significant at a 1% level

Model 2 includes an AR(1) term to reduce the reported negative autocorrelation. The price elasticity for applications by New Zealanders is 0.65, implying that a 1 per cent reduction in the cost of an application resulted in a 0.65 per cent increase in patent applications. A dummy variable for the 1869-71 period, to allow for inventors delaying or bringing forward applications to choose the fee structure that best suited them, was significant. There was some evidence that a dummy variable for the period from 1890, when the cost of a 14-year patent increased, were also significant although this been omitted since autocorrelation increased. Indeed, analysis of the I(1) variables (see online appendix S3) indicated cointegration between the cost of a 14-year patent and the number of these patents per capita by New Zealanders, with the strongest Granger causality running from cost to 14-year patents. A Breusch-Godfrey serial correlation LM test showed the null hypothesis of serial correlation could be rejected for the models. Robust standard errors are reported. A Jarque-Bera test indicated the residuals in the models were normally distributed.

There is inadequate data to test the importance of some of the variables, such as the percentage of the population who were engineers and relative factor prices, which affected patent applications in Victoria.<sup>52</sup> Patent expenditure and GDP per capita are both I(1), but there was only weak evidence of a cointegrating relationship between the two variables. Stronger relationships were evident between expenditure on particular types of patents and output in related areas, with output often preceding increases in patents.

## V

Despite lower application fees and higher levels of patenting, lower income groups continued to find patenting fees prohibitive in Britain during the nineteenth century.<sup>53</sup> Research by Kuegler, however, has found that after the 1884 reduction in patent fees British inventors with lower assets made a higher proportion of patent applications and patent renewals.<sup>54</sup> Furthermore, in Victoria there was a decline in the proportion of patenting by professionals and merchants, including engineers, and an increase in patenting by tradespeople, by farmers,

<sup>52</sup> Magee, Knowledge generation, p. 96.

<sup>53</sup> MacLeod et al., 'Evaluating inventive activity', pp. 539, 545-546.

<sup>54</sup> Kuegler, 'The responsiveness of inventing', pp. 20, 44.

and by other occupations over time.<sup>55</sup> This section investigates patenting by New Zealand occupational groups, and uses detailed time-series data to examine how reductions in patent fees affected the proportion of patent applications by those working in lower income occupations.

Excluding declarations partly about status, such as ‘gentleman’, almost 90 per cent of patentees in our sample listed their occupation. This is the same percentage as in the self-governing colony of Victoria for a comparable period<sup>56</sup> facilitating comparisons. Uniquely, comparisons are also made with broadly equivalent 1886 Census occupation data for New Zealand males.<sup>57</sup> New Zealand occupation data was coded using the OCCHISCO classification.<sup>58</sup>

As in other patent systems, engineers dominated patenting in New Zealand. Indeed, Table 7 shows that 21.1 per cent of patentees stated they were an engineer, and this group accounted for 24.1 per cent of expenditure on patent fees and required expenditure. In the nineteenth century the occupation of ‘engineer’ was widely used by skilled trades workers who had received technical training through apprenticeships and practical experience.<sup>59</sup> The percentage of patent applications by engineers was slightly lower than the 26.8 per cent share of patents held by engineers in Victoria. While 16 per cent of applications by patentees living in New Zealand were by engineers, only 1.8 per cent of males in the 1886 New Zealand Census described themselves as an engineer.

People in farming occupations applied for 8.4 per cent of patent applications in New Zealand, which was more than twice the 2.9 per cent of patents farmers applied for in Victoria. Farmers made 12.1 per cent of patent applications by New Zealanders, and 12.3 per cent of patent expenditure by New Zealand inventors. Just over 29 per cent of New Zealand’s male working population stated that they worked on a farm in the 1886 Census, although some of these were farm labourers (7 per cent of the male population), or forestry workers (1.6 per cent), or shepherds (1.0 per cent), and these occupations were rarely listed on patent applications.

Merchants and salespeople accounted for 7.8 per cent of patent applications in New Zealand. This was substantially higher than their 4.8 per cent share of patent applications in Victoria. The 7.6 per cent of patent applications by New Zealand merchants and salespeople was only slightly higher than the 6.8 per cent of the male workforce in the 1886 Census who stated these occupations.

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<sup>55</sup> Magee, *Knowledge generation*, pp. 66-67.

<sup>56</sup> *Ibid.*, p. 66.

<sup>57</sup> Office of the Registrar General, *Results of a census*, pp. 301-304.

<sup>58</sup> Roberts, Woollard, Ronnander, Dillon and Thorvaldsen, ‘Occupational classification’.

<sup>59</sup> *Ibid.*, p. 65.

Managers and manufacturers accounted for almost 4.8 per cent of patent applications in New Zealand, which was higher than the 2.9 per cent in Victoria, but just 3.0 per cent of patent applications and 3.3 per cent of expenditure were by New Zealanders in these occupational groups. The 1886 Census data indicated only 0.6 per cent of the male population were managers or manufacturers. However, this probably partly reflects managers specifying other occupations, while since manufacturing rapidly expanded in the 1880s<sup>60</sup> analysing later census data would probably reveal more manufacturers. Electricity was a new technology in the 1880s and New Zealand electricians patented at very high rates, with even in the 1896 Census only 0.08 per cent of New Zealand's male workforce reporting they were an electrician.

Blacksmiths made 3.5 per cent of total patent applications in New Zealand, compared to 2.4 per cent in Victoria. In addition, blacksmiths made 4.8 per cent of patent applications and 4.9 per cent of expenditure by New Zealanders, while just 2.6 per cent of men in the workforce stated they were a blacksmith in the 1886 Census.

Miners made 1 per cent of total patent applications, although metallurgists and mining engineers and proprietors more than doubled the proportion of patentees working in mining related occupations. New Zealand miners accounted for 1.1 per cent of patent applications, but other mining occupations were less important than when patent applications by those living overseas were also included. Expenditure results reveal similar patterns. However, 1886 Census data indicated 7.0 per cent of the male population were miners, and data from other censuses<sup>61</sup> also indicates New Zealand miners were under-represented in patenting.

Representation of trade workers in patenting occurred through occupations such as plumbing (1.5 per cent of all patent applications, 2.1 per cent by New Zealanders), coach building (1.6 per cent and 2.3 per cent of applications), carpentry (1.2 per cent and 1.7 per cent of applications) and building (1.0 per cent and 1.3 per cent of applications). There was over-representation of some trades occupations, such as coach and other builders, in patenting by New Zealanders relative to the 1886 Census.

However, the occupations usually thought of as least skilled accounted for few patents. Collectively all occupations that included the word labourer (except agricultural occupations) made 0.5 per cent of all patent applications and 0.7 per cent of applications by New Zealanders. In contrast, over 10 per cent of New Zealand working men at the 1886 Census simply stated they were a 'labourer', and adding railway and waterfront labourers increases this group to 14 per cent of the male population. Data from other censuses produces similar results.

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<sup>60</sup> Greasley and Oxley, 'Knowledge, natural resource abundance'.

<sup>61</sup> Bloomfield, Handbook of historical statistics, pp.126-133.

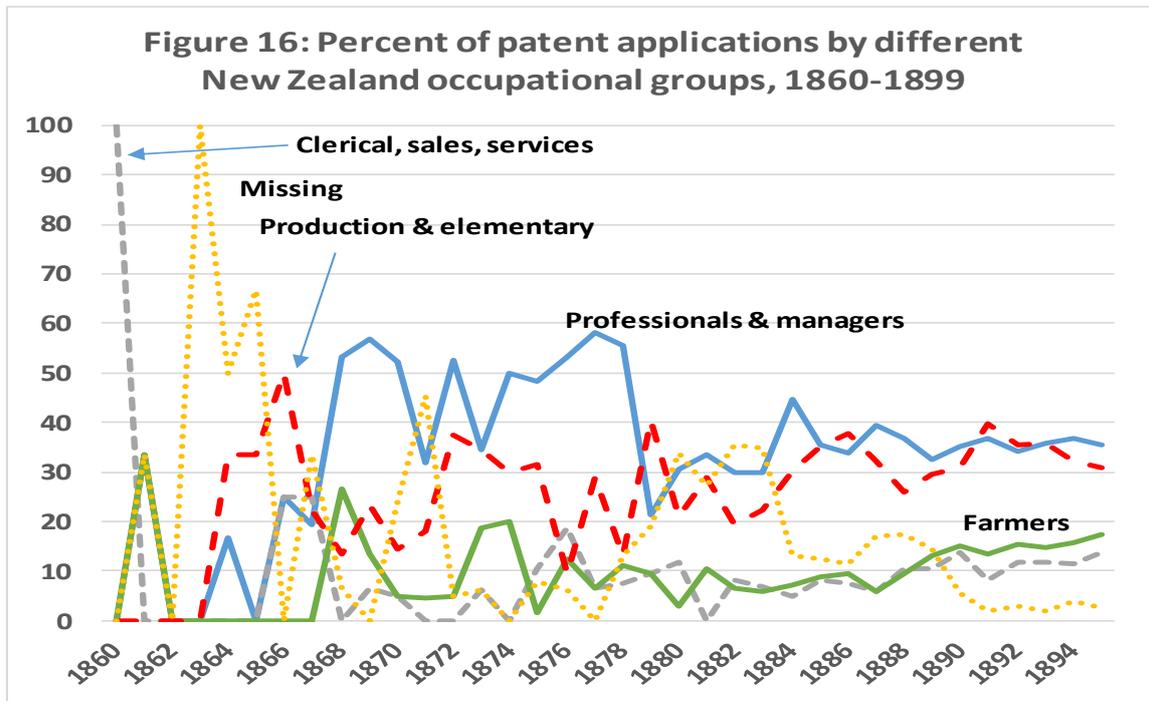
Just over 3.4 per cent of patentees stated they were a ‘gentleman’, which often meant they were of independent means, while 0.6 per cent gave their occupation as ‘inventor’. Among patentees living in New Zealand the proportion of gentlemen more than halved to 1.6 per cent, and this percentage fell sharply from the early 1880s. Just 0.05 per cent of the male workforce gave their occupation as being a gentleman at the 1886 Census. However, the comparable statistic for the 1896 Census was 0.65 per cent, suggesting that the 1886 Census count for gentlemen is not representative of the entire time period. Comparing the results for engineers, manufacturers, chemists, and electricians suggests that New Zealand patentees tended to be less skilled, on average, than foreign patentees.

The results for the main HISCO groups in Table 8 shows that the professionals group, which included most engineers, accounted for 40.2 per cent of total patent expenditure and 29.8 per cent of patent expenditure by New Zealand patent applicants. In contrast, at the 1886 Census just 6.7 per cent of New Zealand’s male working age population were professionals.

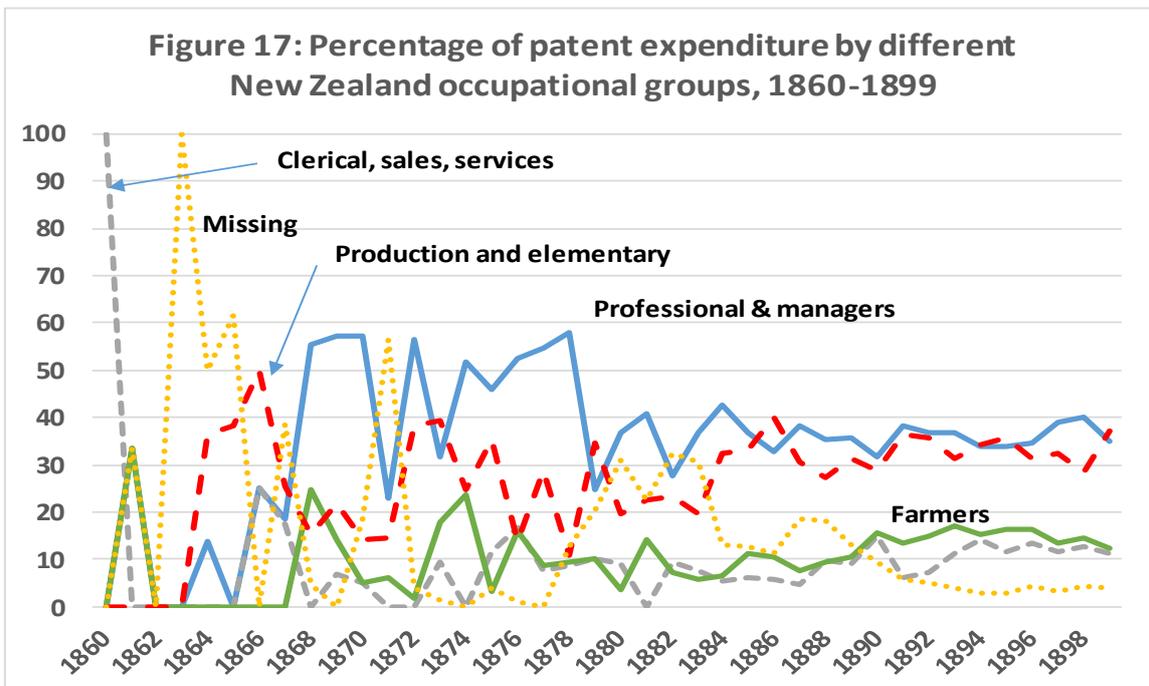
However, elementary occupations and labourers, who were in HISCO group nine, made only 6.4 per cent of patent applications by New Zealanders and paid just 5.6 per cent of patent expenditure, despite constituting 21 per cent of New Zealand’s male working age population. Applications and expenditure by this group were predominantly by carpenters, joiners, printers, and painters. Production trades workers, who are the second lowest group in HISCO, paid 18.2 per cent of patent fees and associated costs by New Zealanders, but were only 10.0 per cent of the 1886 male working age population. This group includes blacksmiths, coach makers, saddlers, bootmakers, and electrical workers. Table 8 shows that the HISCO groups who patented at the lowest levels were clerical workers (such as office workers) and service workers (such as restaurant and household workers, police, and prison guards). New Zealand sales workers’ 6.9 per cent of patent expenditure was similar to their 6.8 per cent share of the male workforce in 1886.

Merging applications by New Zealanders into four main categories (plus missing) for Figures 16 and 17 reveals that in the late 1860s production and elementary occupation workers, who were in the bottom HISCO groups, for a brief period made the most patent applications and expenditure. Professionals and managers then dominated New Zealand patent applications and expenditure during the 1870s, which was when initial fees and required advertising costs were particularly onerous (see Figures 1 and 2). The reduced cost of an initial patent application in the early 1880s was associated with a decrease in the proportion of patenting by New Zealand professionals, a higher percentage who did not report their occupation when applying for a patent, and a gradual increase in patenting by other occupational groups. Indeed, from the early 1880s combined patent applications and expenditure by New Zealanders in the three lowest HISCO occupational groups were almost as high as for professionals and managers. Together with the increase in patent applications,

this suggests that reductions in the cost of an initial application fulfilled their goal of increasing patenting by skilled trades workers.<sup>62</sup> However, the proportion of applications from the least skilled occupations, such as labourers and miners, remained low. In particular, during the 1890s New Zealand labourers accounted for just 0.75 per cent of expenditure on patents by New Zealanders.



Source: As for Figure 3.



Source: As for Figure 3.

<sup>62</sup> *New Zealand Parliamentary Debates*, 4 Nov. 1879, p.66.

**Table 7: Occupations of Applicants for Patents Weighted by their Share of Patent Applications  
and also for New Zealand by their Expenditure on Patents**

Occupations	All Patentees			New Zealand Patentees			1886 NZ	Victoria (Magee)	
	Patents	Applications %	Expend %	Patents	Applications %	Expend %	Male Popn%	Patents	Applications %
Engineers	2,594	21.1	24.1	1,221	16.0	16.6	1.8	2719	26.8
Farmers, forestry & fishing	1,037	8.4	6.4	927	12.1	12.3	29.3	298	2.9
Merchants & sales	957	7.8	7.0	580	7.6	6.9	6.8	490	4.8
Managers & manufacturers	586	4.8	5.7	233	3.0	3.3	0.6	298	2.9
Blacksmith & metalworkers	435	3.5	3.0	368	4.8	4.9	2.6	246	2.4
Gentlemen	415	3.4	4.5	121	1.6	2.6	0.05	98	1.0
Doctors and other medical	261	2.1	2.0	160	2.1	2.0	0.30	-	-
Chemists and pharmacists	245	2.0	2.3	100	1.3	0.8	0.25	242	2.4
Coach builders	192	1.6	1.2	178	2.3	2.4	0.6	114	1.1
Plumbers and pipe makers	185	1.5	1.0	157	2.1	1.8	1.3	134	1.3
Architect	151	1.2	1.0	116	1.5	1.8	0.1	117	1.2
Carpenters and joiners	148	1.2	0.8	133	1.7	1.4	3.7	113	1.1
Other mining sector	139	1.1	1.3	34	0.4	0.3	0.02	-	-
Electricians & lines	138	1.1	2.4	33	0.4	0.3	0.01	162	1.6
Miners	126	1.0	0.8	88	1.1	1.3	7.0	216	2.1
Builders	120	1.0	0.8	98	1.3	1.4	1.4	98	1.0
Machinists	113	0.9	1.1	69	0.9	0.8	0.8	504	5
Labourers	57	0.5	0.3	56	0.7	0.6	10.2	-	-
Other	4,385	35.7	34.3	2,983	39.0	38.5	33.3	-	42.2
<b>Total</b>	<b>12,283</b>	<b>100</b>	<b>100</b>	<b>7,653</b>	<b>62.3%</b>	<b>44.9%</b>	<b>100</b>		<b>100</b>

Sources: As for Figure 3; Office of the Registrar General, *Results of a census*, pp. 301-304; Magee, *Knowledge generation*, pp. 66-67.

**Table 8: Occupation Results for the Nine Main HISCO Groups  
with Patent Applications Weighted by Share of patent Applications  
and also by Expenditure on Patents**

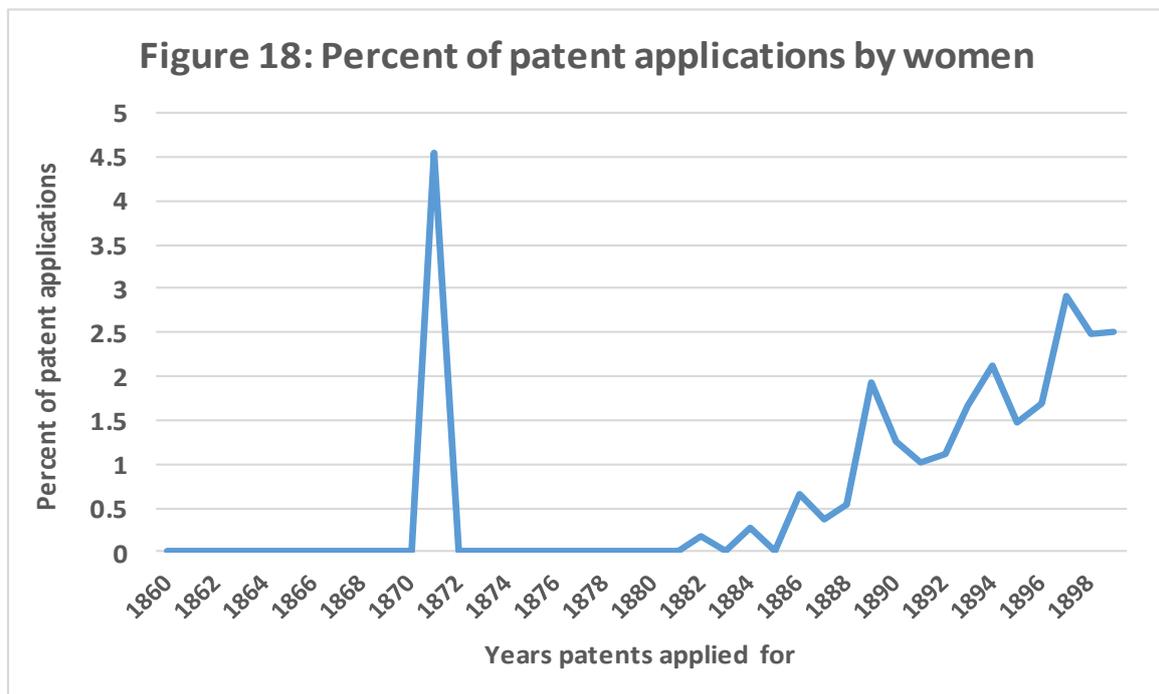
Group	Occupation group	All patentees			New Zealand Patentees			1886 NZ Census
		Patents	Applications %	Expenditure %	Patents	Applications %	Expenditure %	Male working popn %
1	Professionals	4,661	38.0	40.2	2,324	30.4	29.8	6.7
2	Administrators and managers	1,080	8.8	9.3	543	7.1	8.0	2.3
3	Clerical	178	1.5	1.0	144	1.9	1.7	5.2
4	Sales	957	7.8	7.0	580	7.6	6.9	6.8
5	Services	126	1.0	0.8	86	1.1	1.0	4.2
6	Farmers	1,037	8.4	6.4	927	12.1	12.3	29.3
7	Processing including metal	668	5.4	4.6	508	6.6	6.7	14.5
8	Production trades workers	1,790	14.6	13.4	1,400	18.3	18.2	10.0
9	Elementary occupations & labourers	576	4.7	3.3	488	6.4	5.6	21.0
	Other	1,210	9.9	13.9	652	8.5	9.8	0.01
	Total	12,283	100.0	100.0	7,653	62.3	44.9	100.0

Sources: As for Table 7.

## VI

The level of patenting by women is an important indicator of their level of participation in the economy. Between 1860 and 1899 just 1.5 per cent of patent applications were by women, although this is slightly higher than the 1.1 per cent of patent applications made by women in Victoria between 1854 and 1901.<sup>63</sup> Both total applications by women and the proportion of applications by women trended upwards over time, with women making 2.5 per cent of applications in 1899. In contrast, by the late 1890s women accounted for just under a per cent of patents granted in the United States, although the trend there was also upwards.<sup>64</sup>

The first woman to make a patent application was Matilda Lang, who lived in Melbourne, Victoria, and who in 1871 patented an improvement for washing and scouring clothes, wool, and flax. Since there were only 38 patent applications in 1871, her letter of registration caused the spike in Figure 18. The second patent application solely by a woman was by Elisabeth Barton of Dunedin, New Zealand, for a new bedspread in 1884, and occurred in the same year as the *Married Women's Property Act* increased property rights for women. Barton's invention was widely reported as pleasing advocates of women's rights.<sup>65</sup> There were 30 applications by women inventors during 1898, five of which concerned clothing.<sup>66</sup>



Source: As for Figure 3.

<sup>63</sup> Magee, Knowledge generation, p. 64.

<sup>64</sup> Khan, The democratization of invention, p. 135.

<sup>65</sup> 'Notes' in Timaru Herald, 17 Jan. 1885; 'Quite a scare' in New Zealand Herald, 7 Jan. 1885.

<sup>66</sup> Registrar Patents Office, AJHR H-10 (1899), p. 1.

**Table 9: Occupations of All Female Applicants and New Zealand Female Applications for Patents Weighted by their Share of patent Applications and their Expenditure on Patents**

	All female patentees			All New Zealand female patentees			1886 Census
	Patents	Applications %	Expenditure %	Patents	Applications %	Expenditure %	Percent of Female Working Age Population
Wife, widowed or married	68	37.3	35.7	54.5	41.0	41.1	72.6
Gentlewoman or lady	36	14.2	10.3	13	9.8	4.2	0.03
Spinster	12	6.6	5.8	8	6.0	5.5	NA
Dressmaker and clothes	10.3	5.6	7.3	8.3	6.2	7.0	6.6
Farmers	8.5	4.7	5.5	6.5	4.9	7.1	0.7
Hotel & domestic workers	4.8	2.7	3.0	4.8	3.6	4.9	14.3
Teachers and governesses	4	2.2	1.3	3	2.3	0.8	0.9
Doctors and other medical	3.5	1.9	1.3	3	2.3	1.8	0.39
Merchants and sales	3.5	1.8	0.2	2.5	1.9	0.7	0.76
Machinists	3	1.6	1.2	3	2.3	2.0	1.48
Other including none given	38.9	21.4	28.4	27.8	20.9	24.8	2.2
Total	182.5	100	100	132.9	72.8	62.4	100

*Sources:* As for Table 7.

The most common occupation stated by female patent applicants was married or widowed at 37.3 per cent. For New Zealand female applicants the proportion was slightly higher at 41.0 per cent, but this was considerably less than the 72.6 per cent of New Zealand women who were classified as married or widowed in the 1886 census. Collectively, 14.2 per cent of all female applicants described themselves as a gentlewoman or lady. The 9.8 per cent of New Zealand female applicants who gave these occupations was much greater than the 0.03 per cent of such New Zealand women in the 1886 census. Another 6.6 per cent of all female applicants, and 6.0 per cent of New Zealand female applicants, described themselves as a spinster.

Almost 7.3 per cent of female patentee applicants, and 6.2 per cent of female New Zealand applicants, were involved in making clothes, usually as a dressmaker. In the 1886 Census, 6.6 per cent of New Zealand women gave these occupations. Just over 4.6 per cent of female patentees and 4.9 per cent of New Zealand female applicants described their occupation as a farmer. This was considerably higher than the 0.7 per cent of such women in the 1886 census. Teaching, nursing, and being an artist were also relatively important occupations for female patentees, and these groups were over-represented in patenting in relation to their share of New Zealand's female population. Similarly, the small proportion of New Zealand women who were merchants or machinists were over-represented in patenting. Although in the 1886 Census 14.3 per cent of New Zealand women were hotel or domestic workers, this low paid group made just 3.6 per cent of applications by New Zealand women. Female patentees disproportionately tended to be of independent means or working in relatively high-income occupations.

No female patentees described themselves as an engineer, but there was one mining proprietor. There was positive newspaper coverage of technological innovation in mining by former Dunedin resident Alice Cornwall, who had recovered from a disastrous marriage to rebuild her family's economic fortunes.<sup>67</sup> Newspapers also positively commented on inventions by Ada Frances Cole, who was a machinist, for well-sinking equipment during the 1880s.<sup>68</sup> Inventions by women were often for household purposes, medicinal products, and clothing, but also included engineering, mining, and manufacturing patents.

New Zealand's indigenous Maori population constituted at least six per cent of New Zealand's population at every census during the nineteenth century.<sup>69</sup> However, the only patent application by a Maori was by Tare Ruka of Westport, who in 1884 applied to protect

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<sup>67</sup> 'Princess Midas' in *Otago Daily Times*, 31 Jan. 1889.

<sup>68</sup> 'Inventions and inventors' in *Evening Star*, 16 May 1889.

<sup>69</sup> Pool, *Te Iwi Maori*, p.76.

a toothache treatment.<sup>70</sup> Ruka was actively involved in the Maori community, and in promoting their political and cultural needs, and worked in dairy farming and importing.<sup>71</sup> The low level of patenting by Maori reflected their relatively weak economic situation. Maori land ownership fell dramatically during the period studied because of land confiscations and sales. Language and cultural differences also limited Maori participation in the economy. By the 1870s Maori were largely engaged in subsistence farming and wage labour in isolated rural areas, although some Maori were becoming successful sheep farmers<sup>72</sup> Maori expertise was acknowledged in areas such as flax growing and processing,<sup>73</sup> and Maori expertise was used by four inventors to differentiate their patents. However, this expertise did not result in patent applications by Maori.

Nineteenth century New Zealand migrants overwhelmingly came from the British Isles. However, New Zealand also had a small Chinese population, which between 1874 and 1881 was over one per cent of New Zealand's population. Three Chinese patentees lived in New Zealand, with the most prolific making three patent applications. All the Chinese patent applications were from the 1890s when New Zealand's Chinese population was falling.

## VII

Changes in patent law and costs from 1860 in New Zealand were similar to changes in the United Kingdom and in other self-governing British colonies. As in Britain and in Victoria, there was strong growth in per capita patent applications in New Zealand from the early 1880s when initial application fees and other costs were sharply reduced to encourage applications, and to encourage patenting by additional occupational groups. Indeed, the log of the total cost of an initial application, which included both fees and required advertising costs, explains most of the variation in patent applications per capita by New Zealanders. In contrast, overseas patent applications and total expenditure on patents per capita in New Zealand showed relatively consistent growth.

People living in New Zealand made 62 per cent of patent applications, but these applications disproportionately lapsed or were not renewed. Indeed, from the early 1880s consistently more than half of patent applications by New Zealanders were abandoned, compared to less than a fifth of patent applications by overseas inventors. As a result, even considering required advertising expenditure, the unit record data used in this article indicates that New Zealand patent applicants only paid 45 per cent of patenting fees and required

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<sup>70</sup> 'Quite a scare' in *New Zealand Herald*, 7 Jan. 1885.

<sup>71</sup> 'The Governor's visit and the Maoris' in *Westport Times*, 12 Feb. 1886; 'The bankruptcy business' in *Westport Times*, 20 May 1884.

<sup>72</sup> Monin, 'Maori economies', pp.141, 145.

<sup>73</sup> Flax Commissioners, (AJHR, D-14, 1870), pp.24,39; Firth, *Economics of the New Zealand Maori*, pp.61-67, 87.

advertising expenditure. When the data was weighted by expenditure on patent fees New Zealand was considerably more dependent on imported intellectual property than patent application statistics suggested. This provides further evidence that unweighted patent application counts may be misleading.<sup>74</sup> The effects of patent fees on the number of 14-year patents appeared to vary, although the results suggested that the cost of a 14-year term affected the number of such patents by New Zealand inventors. Overseas inventors largely switched from letters of registration to letters patent after the cost advantage of the former disappeared during the early 1880s.

Occupation data showed that patents applied for by engineers accounted for almost a quarter of total expenditure on patents. Unique comparisons with census data confirmed that New Zealand engineers patented at a much higher rate than the male population as a whole. Farmers were a more important group for patent applications than in equivalent data for the Australian colony of Victoria, and their patents involved about 12 per cent of patent expenditure by New Zealanders. Skilled trade workers, such as blacksmiths, electricians, and builders, were over-represented in patent applications and expenditure. Lower patenting costs in the early 1880s were associated with increased patenting by lower ranking occupational groups, indicating that, as policy makers had intended, a wider range of occupational groups were finding patenting affordable. However, unskilled workers, such as labourers and miners, continued to make relatively few patent applications.

Women accounted for a growing share of patent applications from the early 1880s, and made 2.5 per cent of patent applications in 1899. Patenting by women in New Zealand occurred at slightly higher levels than in the United States or in Victoria. Female patentees tended to be disproportionately of independent means, or working in potentially relatively well paid occupations. Despite consistently being over six per cent of New Zealand's population, there was only one patent application by a New Zealand Maori. Only three Chinese living in New Zealand made patent applications.

The new unit record data considered here shows that by 1899 the New Zealand patenting system had become accessible to New Zealand men of European origin from a wider range of occupational backgrounds than during the 1870s. This reflected fee reductions in the early 1880s that had facilitated high per capita patenting rates, and had successfully increased the openness-of-opportunity of patenting to skilled trades workers. Nevertheless, patenting by unskilled workers, by women, and by non-European population groups remained very low, although there was growing public and official interest in patenting by women. Furthermore, the majority of patent fees expenditure continued to be paid by overseas inventors.

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<sup>74</sup> Streb, Baten, and Yin, 'Technological and geographical knowledge', p. 349, Nuvolari and Tartari, 'Bennet Woodcroft and the value of English patents', pp. 98-99.

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