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Secrets for Sale? Innovation and the Nature of Knowledge in an Early Industrial District: The Potteries, 1750-1851*

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Abstract:
This paper investigates innovation and knowledge in the North Staffordshire Potteries during the eighteenth and early nineteenth centuries. It evaluates new empirical evidence of formal and informal patterns of knowledge creation and dissemination in order to highlight tensions between forms of open knowledge sharing and the appropriation of returns to innovative activity. By presenting new patent data it shows that formal protection was not a widespread strategy in the industry. It uses patent specifications to determine what specific types of knowledge were, and could be, patented in the district, and by whom. A range of sources are used to demonstrate evidence of innovation and knowledge appropriation outside of the patent system. The paper identifies distinct types of knowledge in the industry and shows how differences in these led to a range of strategies being employed by potters, with the role of secrecy highlighted as a particularly prevalent and effective strategy.

1. Introduction

A global feature of pottery production throughout history has been the vast amount of knowledge and skill required to produce a diverse range of high quality products. The North Staffordshire Potteries during the eighteenth and nineteenth centuries were characterised by a growing body of just such useful and practical

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knowledge about the materials, processes and skills required to produce local goods that sold in global markets.[1] The region flourished, exporting over sixty-two million pieces to the global market in 1836 which were produced under conditions of extreme social and geographical proximity where tacit knowledge and competition loomed large.[2] The Potteries quickly became a 'cauldron of creativity' which produced much of the earthenware, ceramics and porcelain often held up as key commodities of the Consumer Revolution.[3] Messrs Spode, Minton, Copeland and the celebrated Wedgwood dynasty led as pioneering figureheads for innovation and style, driving forward the development of new products and production methods.

Although it was not one of the more traditional lead sectors of the economy during the British Industrial Revolution, pottery production in North Staffordshire is an example of a 'classic' industrial district. A strong sense of local identity emerged early in the region's history and for almost 250 years the district dominated British earthenware production; generating and meeting ever increasing demand for 'Staffordshireware'. Unlike its more famous cousins, such as the cotton and metalworking districts of Lancashire and Sheffield, the Potteries did not experience the 'terminal' phase of its life-cycle until the close of the twentieth century.[4] The English pottery industry had concentrated within the six- by three-mile region by the middle of the eighteenth century with pot shops and firing ovens crowded together, often just feet apart. It continued to grow into the nineteenth century in terms of the number of businesses operating, the size of the labour force, resources used, output, and the extent to which it dominated the local economy.[5]

Storper and Venables argue that intense concentration and proximity creates 'buzz' and face-to-face contact between individuals which, alongside other benefits,

[1] Weatherill, *The Growth of the Pottery Industry,* 43.
[2] Table 82, *Tables of the Revenue, Population, Commerce*, 98
[3] Blaszczyk, *Imagining Consumers,* 4-9; Berg, *Luxury and pleasure*; McKendrick, 'Josiah Wedgwood' in *The Birth,* eds. McKendrick *et al*, 100-145
[4] Popp and Wilson, 'Districts, networks and clusters', in *Industrial Clusters,* eds. Popp and Wilson, 14-15.
[5] For estimated aggregate figures see: Weatherill, *The Growth of the Pottery Industry*, 440-453

is crucial for 'creative activities' based on rapidly changing tacit knowledge that is difficult to codify.[6] This suggests that the Potteries region described above would stand to benefit from the properties of such 'buzz'. However, in specific sites of intensive material production such proximity also creates tensions between knowledge transfer and spillovers, and the need to retain competitive advantage. Pottery production continued to be dominated by knowledge intensive, craft-based processes and the skills of the master potter until well into the second half of the nineteenth century. Reliable automated machinery was in general use only by the 1870s.[7] Moreover, unlike other specialised artisanal trades such as weaving or brewing, and despite the importance of knowledge to the trade, the pottery industry did not have a legacy of a formal craft guild or institution with codified rules to govern behaviour and access to vital knowledge and skills. As such, we do not yet have much clear empirical evidence to suggest how potters in North Staffordshire during the eighteenth and nineteenth centuries sought to protect their knowledge in a fiercely competitive industry that had developed a strong sense of local identity.

This paper considers the nature of knowledge in the North Staffordshire pottery industry between 1750 and 1851. It investigates formal and informal institutions of knowledge appropriation and demonstrates how the types of knowledge being produced and used in the industry determined the actions and strategies of potters and non-potters. The subject is addressed using new patent data and a detailed analysis of the specifications, alongside a range of contemporaneous qualitative evidence. The choices and behaviour of individuals are determined and evaluated through the extent to which they revealed the knowledge underpinning key innovations. The type of knowledge being revealed or kept secret is also examined and a new typology of knowledge in the pottery industry is proposed.

The paper begins with a short review of the existing literature and a discussion of the discovery of a single, hitherto unknown and conceivably unique, newspaper

[6] Storper and Venables, 'Buzz', 351-370.
[7] Burchill and Ross, *A History,* 154; Lamb, 'The Press', 6.

advertisement from 1795 which purports to offer secrets for sale. The first section then begins the empirical investigation into knowledge appropriation which uses patent data and specifications to determine who was patenting what, and where. All known pottery patents were collated and examined to identify trends in patenting activity and present the empirical landscape of formal protection of intellectual property in the pottery industry over time and space. The geographical and occupational characteristics of these data are analysed. The paper then turns to examine the knowledge held within pottery patents that were granted through a close reading of the specifications themselves. This allows for the proposal of a typology of the nature of knowledge in the industry that goes beyond the contested binary tacit/explicit interpretations that are applied across a variety of disciplines.[8]

The second part of the paper then presents evidence of innovation outside of the patent system to further refine our understanding of the nature of knowledge. It uses ephemeral trade literature and publications, exhibition reports, award citations and sales catalogues to present further examples of different types of knowledge being shared, protected and kept secret. The evidence presented helps explain the behaviour and strategies of potters who kept their knowledge secret through informal channels. It also helps us address the extensively studied yet ongoing problem summarised by Moser: 'It is well known that inventors do not patent all their innovations […] but why inventors do not patent is less well understood'. [9]

The paper concludes that patenting was not a widespread strategy used by North Staffordshire potters to protect their knowledge and appropriate returns from the majority of their innovations. Rather, secrecy was highly valued and maintained through a variety of techniques. Knowledge was actively managed by its holders and kept away from outsiders. Crucially, the specific type of knowledge held determined the level of protection required and the action taken. This analysis

[8] For an overview of the tacit/explicit interpretation across various disciplines see Table 1 in Gourlay, 'Conceptualizing Knowledge', 1426.
[9] Moser, 'Why don't inventors patent?', 1.

provides a new case study of a highly concentrated, highly innovative industry in which the tensions between competition, collaboration and knowledge production were at their most acute. The findings provide further empirical and analytical support for Moser's findings that the efficacy of secrecy was industry specific and the key determinant of the propensity to patent and, moreover, that this was underpinned by the degree of scientific or technical knowledge required.[10] They also provide additional evidence concerning the study of collective invention with the region exhibiting some, but not all, of the core features of Allen and Nuvolari's now classic examples.[11]

2. Review

The study of invention and innovative activities during the British Industrial Revolution has developed considerably over the last few decades, with Allen and Mokyr advancing two contrasting views based on induced invention and the concept of the 'Industrial Enlightenment' respectively.[12] Alongside these macro-level studies, a growing body of region and industry specific case studies has progressed close examination of innovation systems and strategies of inventors and producers. Key among these are studies of historical patenting practices which have become increasingly quantitative in attempts to determine their importance as drivers of innovation.[13] There are general limitations concerning the utility of patents given that not all innovations were patented, and not all patents reflected true innovations.[14] The works of scholars such as Moser and Nuvolari have been instrumental in developing new methodologies and approaches which make it possible to address these limitations.[15] Their works have built on and revised earlier studies by Dutton and MacLeod on innovation and patenting in England

[10] *Ibid.,* 3, 25-26
[11] Allen, 'Collective Invention', 1-24; Nuvolari, 'Collective Invention', 347-363.
[12] Allen, 'Why the Industrial Revolution was British', 357-384; Mokyr, *The Enlightened Economy.*
[13] Moser, 'Patents and Innovation', 241.
[14] Schmookler, *Invention and Economic Growth,* 24; MacLeod, 'Strategies for Innovation', 288-9; Mokyr, *The Lever of Riches,* 251.
[15] Moser, 'Innovation without Patents', 43-74; Nuvolari and Sumner, 'Inventors', 95-120; Nuvolari and Tartari, 'Bennet Woodcroft', 97-115.

during the transition to modern economic growth.[16] These developments notwithstanding, further work needs to be done to address differences in the propensity to patent in different historical periods and industries.

An influential concept in this line of enquiry has been that of 'collective invention', a term coined by Allen to describe a process in which innovators freely and openly published and shared knowledge about advances and improvements in an industry.[17] The conclusions he offered were based on observations of the English pig iron industry in Cleveland during the nineteenth century. He identified a framework of communication between firms based on a culture of testing and sharing technical information through two channels: informal disclosure, and formal publication. The role of such disclosure channels was to make new technical knowledge created by firms available to their competitors. In turn, this allowed for cumulative incremental advances in technologies and practices, thus increasing the rate of innovation in the industry.[18] Collective invention, Allen argues, was one of the most important sources of innovation in England during the nineteenth century.

This framework, however, rests on a key characteristic of the chosen industry. Innovation in pig iron production during the nineteenth century predominantly took the form of improved design and construction of blast furnaces. These were large, obtrusive structures ranging from forty to over ninety feet high and were thus very difficult to keep secret or limit knowledge of their existence. If a producer built a new blast furnace, it would be clear to his competitors, especially as the height of a furnace was the key factor in determining the efficiency of fuel consumption.[19] This has clear implications for strategies and decision making regarding secrecy vis-à-vis open knowledge sharing.

[16] Dutton, *The patent system*; MacLeod, *Inventing*.
[17] Allen, 'Collective Invention'.
[18] *ibid.*
[19] See Table 1: *ibid.*, pp. 6-7.

Nevertheless, Bessen and Nuvolari's revisionist approach to historical collective invention argues that knowledge sharing was far more common during the age of industrialisation than perhaps modern studies of innovation, or indeed some historical scholars, are willing to accept.[20] Whilst there has been a huge surge in the study of modern knowledge sharing and competition in innovation studies, a degree of scepticism remains as to how early this behaviour developed and how widespread or stable it was. Far from being 'vulnerable and ephemeral', as Bessen and Nuvolari quote Mokyr, collective invention extended far beyond the Cleveland iron or Cornish steam-engine industry.[21]

An important point to note is that Allen's notion of collective invention is characterised by three features: incremental improvements in technology; firms making knowledge publicly available through 'wilful dissemination'; and the utilisation of this common pool of knowledge resources to further improve technological performance. All of this occurred largely outside of the patent system.[22] Whilst many of the examples discussed by Bessen and Nuvolari are not 'pure' instances of collective invention, exhibiting all these features à la Allen, a European perspective does reveal active and often systematic knowledge sharing among inventors, alongside patent systems. Copying and adapting the innovations of competitors, petitioning for the repeal of specific patents and choosing not to take out patents for their own inventions were strategies adopted by inventors and producers across Europe during the eighteenth and nineteenth centuries.[23] There clearly existed two separate spheres of knowledge creation and dissemination; the formal and the informal. The extent to which one impacted upon the other is not clear and there are calls for more localised research to be conducted in light of this.[24] The close case study that follows will also address these open questions and the assumption that a very low propensity to patent in an industry is accompanied by open knowledge sharing between producers.

[20] Bessen and Nuvolari, 'Knowledge Sharing', 135-156.
[21] *Ibid.,* 136; Mokyr, 'The institutional origins', 81.
[22] Allen, 'Collective Invention', 2; Nuvolari, 'Collective Invention', 361.
[23] Bessen and Nuvolari, 'Knowledge Sharing'.
[24] Nuvolari, 'Collective Invention', 360.

3. Patenting in the English Pottery Industry

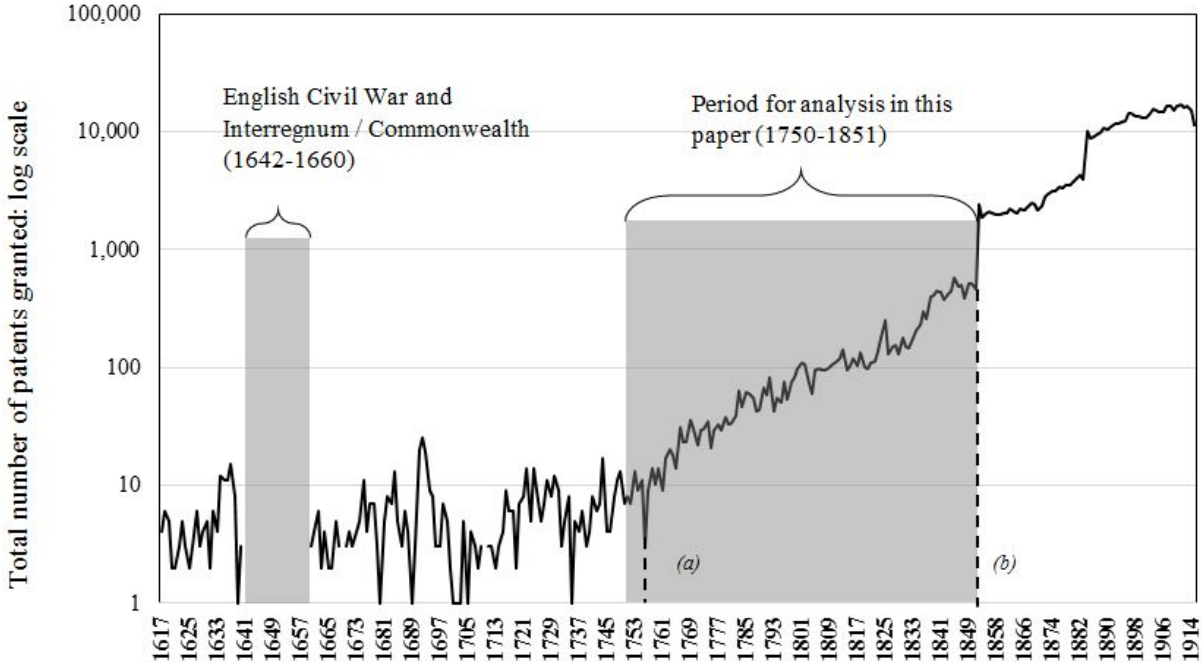
3.1 Trends in pottery patenting

The following discussion uses patent data to set out the empirical landscape of formal protection of intellectual property in the pottery industry of North Staffordshire between 1700 and 1851. It then provides a profile of the patents and patentees to determine which types of knowledge were being patented in the industry, and by whom. The temporal scope is important because 1852 saw the introduction of the Patent Amendment Act which significantly increased the propensity to patent in Britain through a large reduction in the cost of the patent itself. This was accompanied by a new centralised 'British' administrative process, and reforms in the reporting and requirements of specifications.[25]

Figure 1 shows that from the middle of the eighteenth-century patenting took off in England and continued to grow with a marked increase after 1852.[26] The core sources for patents in the English pottery industry are three indexes compiled and published by the Superintendant of Specifications at the Patent Office, Bennett Woodcroft, during the 1850s and 1860s.[27] The *Abridgments* relating to pottery have not hitherto been used widely and to the author's knowledge, this is the first such study to engage with this source in systematic detail.

[25] Bottomley, *The British patent system,* 64-5, 161-168.
[26] Sullivan, 'England's "Age of Invention"', 443.
[27] See 'Patent Sources' in Bibliography for references.

Figure 1: Total patents granted each year in England, 1617-1915

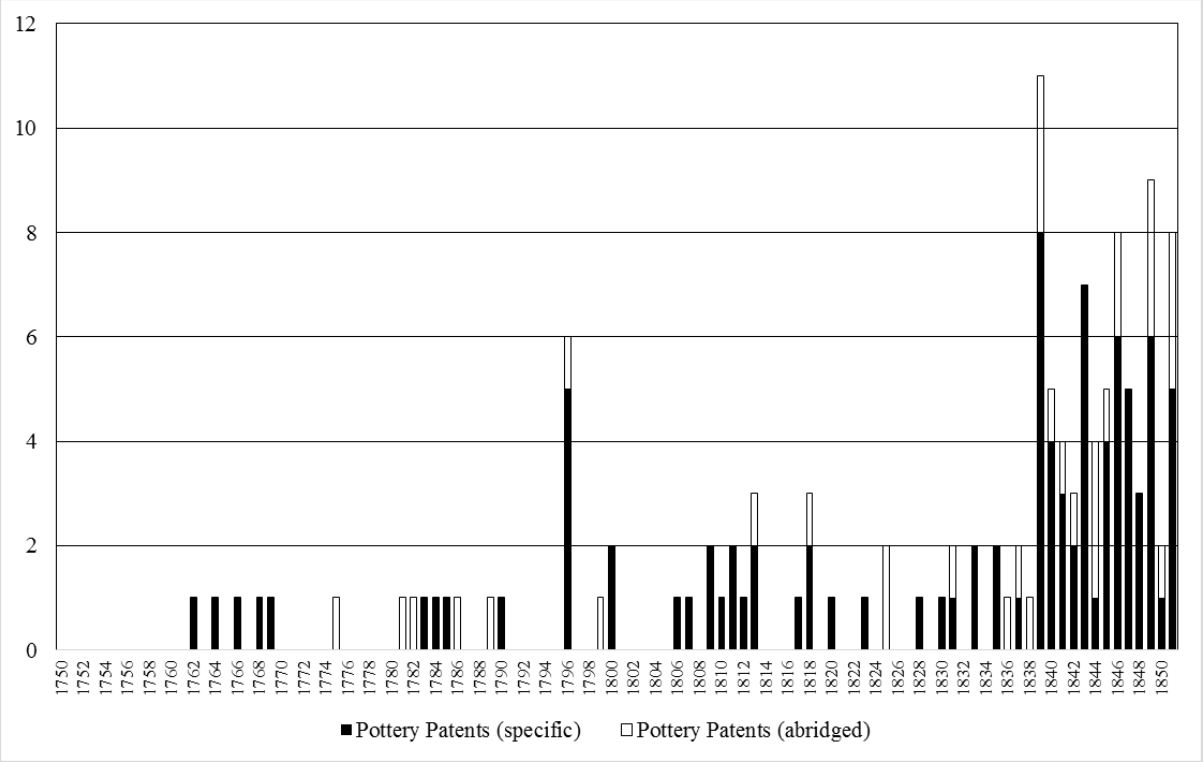


Notes: Yearly observations.
(a) dotted line highlights the structural break point identified by Sullivan.
(b) dotted line marks introduction of Patent Amendment Act, 1852.
Sources: See main text and 'Patent Sources' in Bibliography

At the industry level, pottery did not experience such a strong trend in patenting and the volume of patents granted was extremely low as shown in Figure 2. There were 143 'pottery related' patents granted between 1617 and 1851.[28] The pottery index compiled by Woodcroft may be somewhat misleading due to the chance that any reference by the patentee to a specific industry 'may be entirely speculative'.[29] To mitigate this problem each of the 143 'abridged' specifications have been examined by the author to remove those very broad patents with tenuous or irrelevant references to pottery. This process leaves 108 'specific' patents for the entire period 1617-1851.

[28] Woodcroft, *Patents for Invention.*
[29] Nuvolari and Sumner, 'Inventors', 99.

Figure 2: Number of pottery related patents granted in England, 1750-1851



Notes: The period 1617-1750 has been excluded from this graph. The solid columns represent patents which were specifically for pottery innovations. The hollow columns represent those additional patents in Woodcroft's 'Abridged' list.
Sources: As for Figure 1

Patenting in the industry was minimal until 1839 when there was an increase in patents for machinery of various descriptions. Before this, there was only one year, 1796, in which more than two patents were granted. Of the five patents granted in this year, coincidentally the year after Josiah Wedgwood's death, three were held by one man, his cousin and business partner Ralph Wedgwood.[30] To provide a relative measure, Table 1 shows both the Patent Office's abridged patents and the author's own 'specific' pottery patents as a share of total patents granted in England. Even during the period 1701-1750, which saw considerable attempts outside of Staffordshire to imitate Chinese porcelain and produce English porcelain, pottery patents accounted for only 3.08 per cent of all patents.[31]

[30] It seems at this stage more than a coincidence that Ralph Wedgwood, cousin and partner of Josiah Wedgwood, would patent three innovations in the year immediately following the master potter's death.
[31] The most notable coming from factories at Bow and Chelsea in the 1740s: Holgate, *New Hall*, 1-3.

Table 1: Pottery patents as a share of total patents, 1617-1851

Years	*1617-1700*	*1701-1750*	*1751-1800*	*1801-1851*	*1617-1851*
Total Patents	431	292	1,804	11,484	14,011
Pottery Patents (abridged)	5	9	23	106	143
Share of total	1.16%	3.08%	1.27%	0.92%	1.02%
Pottery Patents (specific)	5	9	16	78	108
Share of total	1.16%	3.08%	0.89%	0.68%	0.77%

Notes: see main text for distinction between abridged and specific patents.

Table 2 shows the pottery patent data alongside those compiled by Nuvolari and Sumner for a similarly highly innovative industry, brewing, over roughly the same period which showed a 'remarkably low propensity to patent'.[32] Given this low number of patents the next stage of analysis is to determine who the patentees were, and what *was* being patented.

Table 2: Brewing and pottery patents, 1751-1850

Years	*1751-1800*	*1801-1850*	*1751-1850*
Total patents	1,804	10,974	12,778
'Genuine' brewing patents	21	62	83
Brewing share of total	1.16%	0.56%	0.65%
Specific pottery patents	16	73	89
Pottery share of total	0.89%	0.67%	0.70%

Notes: Brewing industry data comes from Nuvolari and Sumner, 'Inventors', pp. 103-4. Their 'genuine' brewing patents are comparable to 'specific' patents.

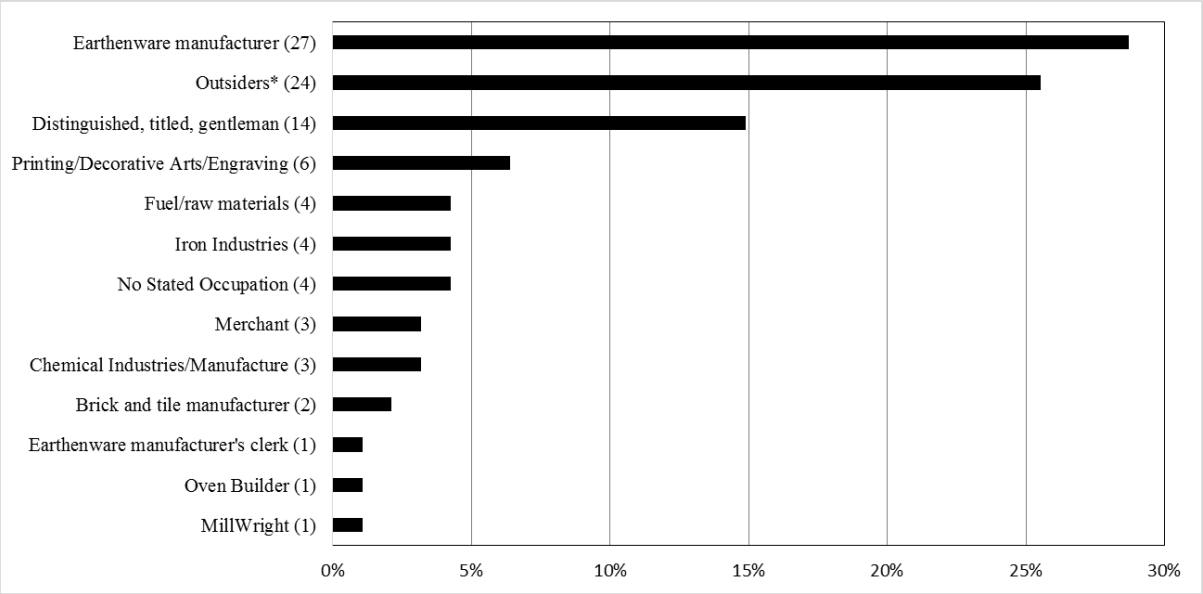
During the second half of the eighteenth century 99 per cent of all patents recorded both the occupation and place of residence of the patentees.[33] The majority of

[32] Nuvolari and Sumner, 'Inventors', 103-4.
[33] MacLeod, *Inventing*, 116.

patentees listed in the newly constructed database as earthenware or pottery manufacturers were highly skilled master potters who ran their own businesses and were highly skilled.[34] Figure 3 shows the occupational distribution of pottery patentees for 1750-1851 and highlights the diverse origins of innovation. Clearly, the few patents that were granted were not restricted to potters. Whilst the largest group of patentees were those directly involved in earthenware manufacture, they only held just under a third of patents. The second largest group were 'outsiders' to the industry; individuals whose occupation was significantly outside of pottery production.[35] The third largest group of patentees were the upper societal elite who held almost 15 per cent of pottery patents. We also see the involvement of related industries such as printing, engraving and chemical industries although the number of patents held is relatively small. Whilst this is a new finding and an addition to the empirical evidence relating to patenting in the Industrial Revolution period, it is not a phenomenon unique to the pottery industry by any means. To continue an earlier comparison, a quarter of all brewing patents for the same period were also held by 'outsiders'.[36]

[34] The majority of them are identifiable through the database of pottery firms compiled from trade directories in an earlier paper.
[35] See notes for Figure 3.
[36] Nuvolari and Sumner, 'Inventors', 104.

Figure 3: Pottery patentees by occupation, 1750-1851 (absolute numbers in parentheses)



Notes: This category contains the following occupations deemed to be significantly outside pottery production: Architect, Builder and Architect, Civil Engineer, Confectioner, Doctor in Philosophy, Doctor in Physics, Engineer, Engineer and Designer, Gas Engineer, Gold and Silver Smith, Mechanical Draughtsman, Paper Maker and Victualler.

3.2 The geography of pottery patenting

Figure 4 shows the distribution of patentees for the whole period 1617-1851 in two categories, potters and non-potters. The concentration of potters with patents in Staffordshire reflects the geographical concentration of the industry and highlights the more scattered distribution of non-potters with patents. Staffordshire, Middlesex (including London), and Surrey remained the dominant sources of pottery patenting. Staffordshire itself accounted for a third of all patents with a peak of 37.9 per cent during the 'boom' period of 1839-1851. The only pottery patent located in Staffordshire that was not held by a resident of the Potteries district was that granted to George Thorneycroft, an iron founder from Wolverhampton whose machine for 'rolling, squeezing, or compressing puddle balls of iron', could also be used for grinding raw materials for the production of pottery.[37] The geography of patenting activity in the pottery industry changed as

[37] Woodcroft, *Patents for Invention,* p. 46.

the 19th century progressed with more patents being granted outside of the region than inside.

Figure 4: Distribution of patents held by potters and non-potters, 1617-1851

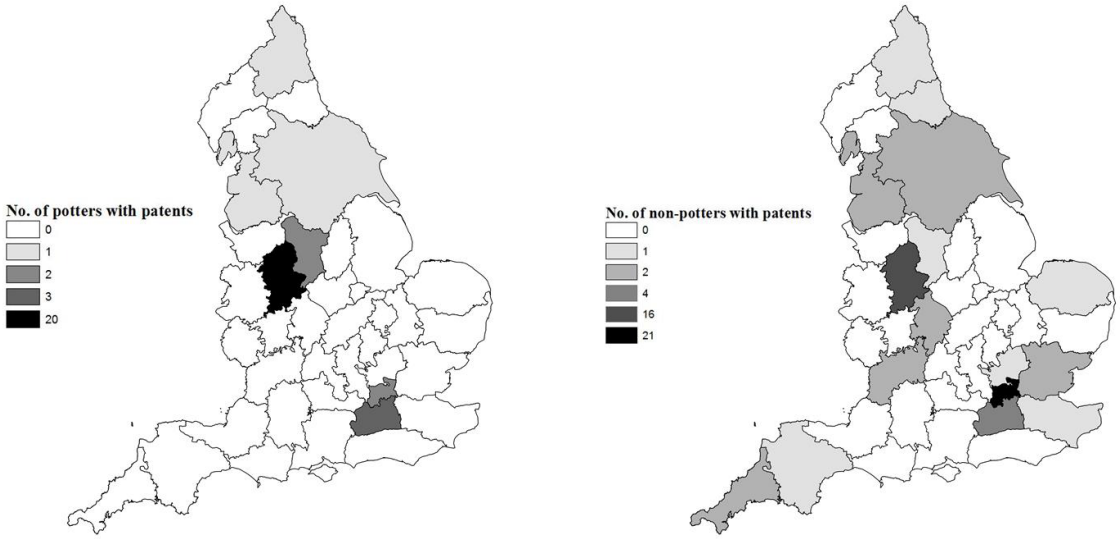


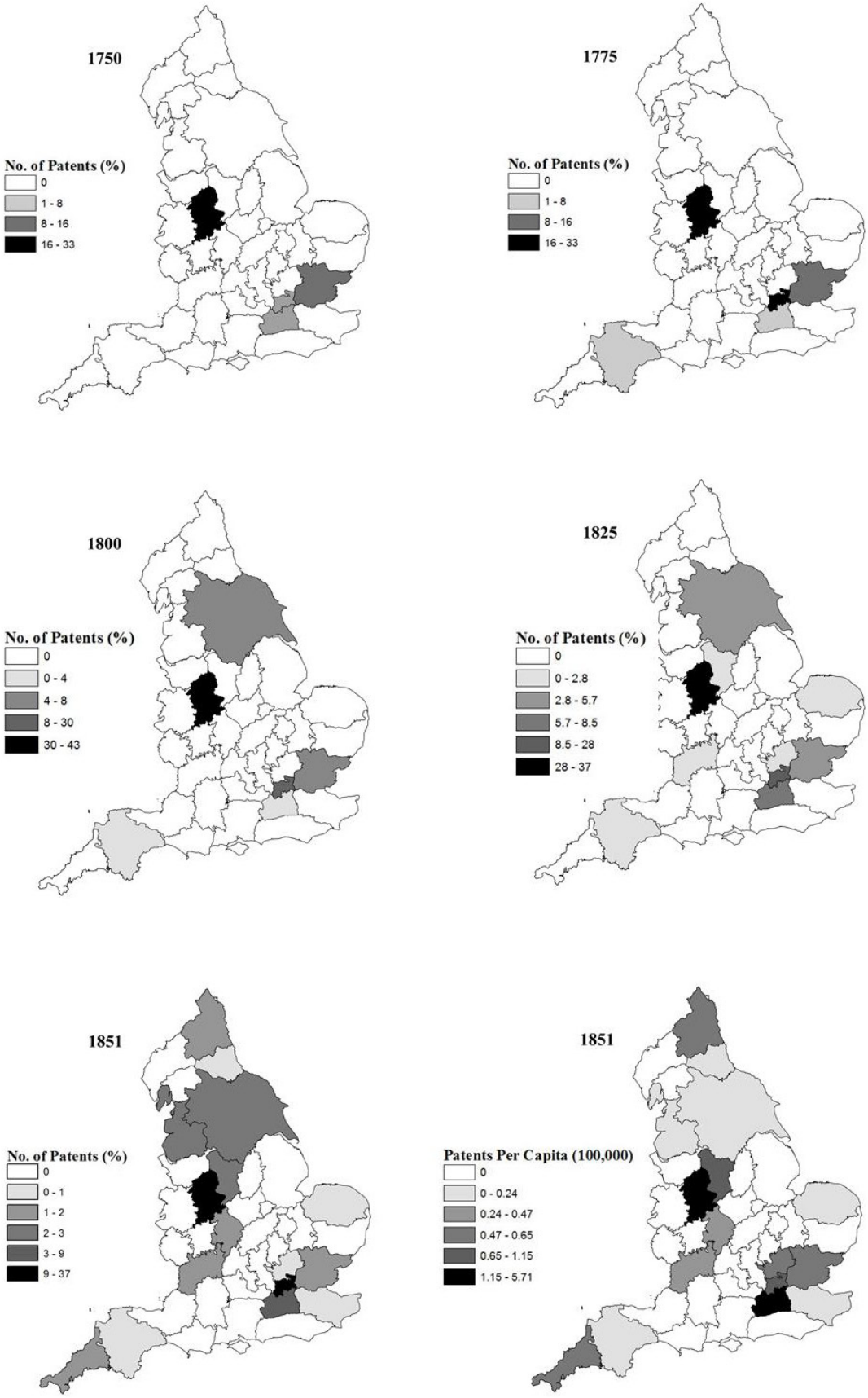
Figure 5 shows the cumulative number of patents in each county by various points in time as a percentage share of total pottery patents, in addition to the patents per capita in 1851. The predominance of London, Middlesex and Surrey alongside Staffordshire is not surprising when we consider national trends in patenting overall. MacLeod estimates that London and the metropolitan parts of Middlesex and Surrey accounted for over half of England's patents, and Inkster suggests a figure of 47 per cent for London during the 1790s.[38] In his study of collective invention in the Cornish mining industry Nuvolari also finds that London, Middlesex and Surrey accounted for over 40 per cent of steam engine patents between 1698 and 1852. He attributes this to the first of Inkster's propositions, the urbanisation and growth of London alongside the geographical location of the patent office.[39] This is interesting when we compare Nuvolari's findings to the ones presented here as there are both parallels and differences between the two. Firstly, steam engine patents were relatively spread out across the country and very few were issued to residents of Cornwall, perhaps a result of the increased

[38] MacLeod, *Inventing*, 119; Inkster, *Science and Technology',* 85.
[39] Nuvolari, 'Collective Invention', 357-8.

usage of steam power for numerous purposes in industrialising areas. Pottery patents, on the other hand, were concentrated in Staffordshire and London's surrounding area. Secondly, Cornwall had an extremely low number of patents for steam engines relative to the 'major contribution' of the region to steam power.[40] Figure 5 shows that the geography of patenting activity in the pottery industry was somewhat more complex. Whilst Staffordshire did command the largest share of pottery patents for a single county, the absolute number was relatively low given the extreme concentration of the industry. Moreover, outsiders to the industry who held patents were spread far more widely across England and located in regions heavily involved in other industries such as Yorkshire, Lancashire, Cornwall and Devon. This shows, therefore, that the low propensity to patent a pottery innovation was exhibited at the industry level rather than the regional level.

[40] *Ibid.,* 358

Figure 5: Cumulative geographical distribution of patents in England



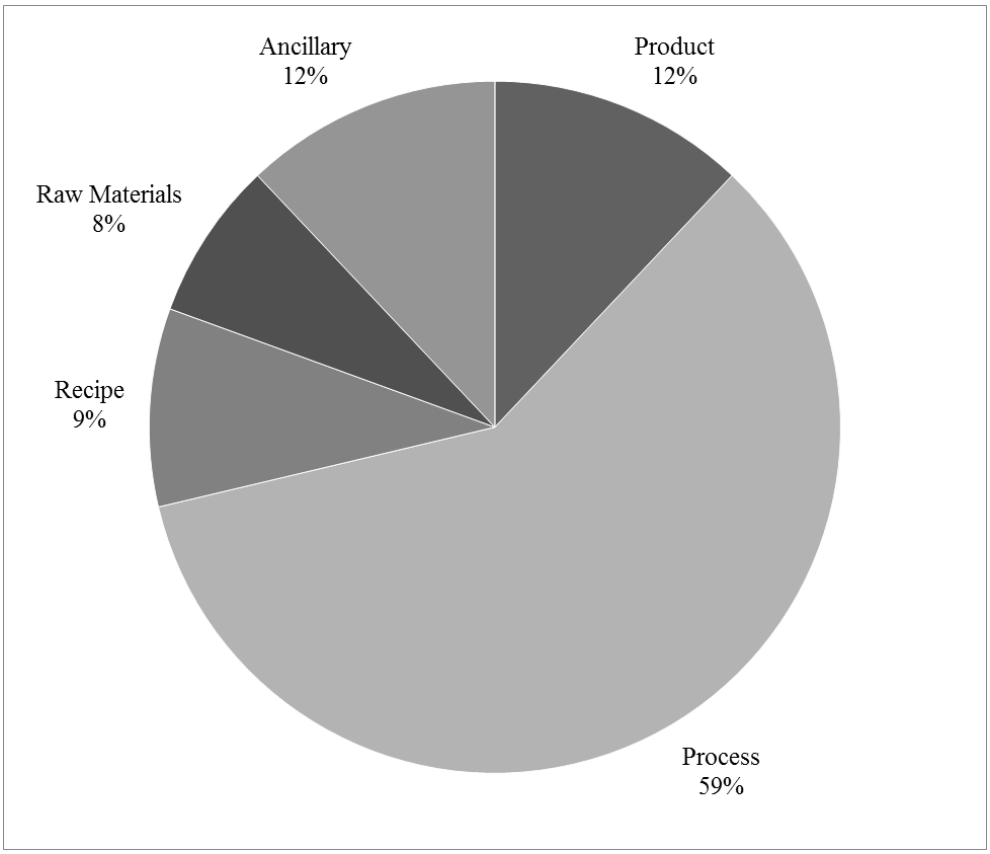
The key points to take from this analysis so far are firstly, patenting was *not* widespread in the pottery industry and was extremely scarce until the 1840s. Patenting an innovation was not a strategy that was widely employed in the industry. Secondly, although earthenware manufacturers themselves were the largest single group of patentees, 71 per cent of patents came from outsiders, most of whom were not resident in Staffordshire. We may therefore confidently draw a similar conclusion from this analysis as has been found in other industries; much of the innovation and inventive activity, and the appropriation of knowledge, was conducted outside the patent system.[41] Such evidence provides a much-needed addition to the body of knowledge on patenting and inventive activity in individual industries to complement the broader studies by Nuvolari, Moser and their co-authors. The question remains as to *what* was being patented and what types of knowledge underpinned those innovations that *were* being patented.

3.3 Knowledge in pottery patents

Patents granted in the pottery industry can be grouped into five main categories: products, processes, recipes, raw materials and ancillary products. Product innovations resulted in an entirely new type of ware, such as Wedgwood's black basalt ware (patent 939). Process innovations increased efficiency of production by altering a stage in the production process, either through mechanical or chemical means. Recipes were new compositions for glazes or bodies which detailed the combination of materials being used. Raw materials innovations dealt with the grinding and preparation of flints, clays and other ingredients. Ancillary innovations, whilst not completely removed from the manufacture of earthenware products, were mainly composed of broader applications of methods and techniques, such as Herbert Minton's patent for earthenware clock faces (patent 13558). The shares of each of these categories are shown in Figure 6.

[41] MacLeod, *Inventing,* 110-111.

Figure 6: Categories of all pottery patents granted in England, 1617-1851



Pottery patents were dominated by process innovations such as John Pepper's improved kiln construction to reduce fuel consumption, or John Ridgway and George Wall's repeated attempts to mechanise flat-ware production in the 1840s.[42] Just 12 per cent of patents were for product innovations such as Cookworthy's English porcelain, or the garden pots of Cutten and Brown.[43] Of the patents issued between 1750 and 1851, over 40 per cent of these related to process innovations which were easily observable and reverse-engineered, such as kilns. The innovations in these patents were largely based on explicit practical or mechanical knowledge rather than tacit scientific knowledge. This type of knowledge was visible, had been embedded and articulated clearly in an object, and was therefore more easily defensible using a patent.

[42] Patents 2140, 8338, 8339, 8340, 9901, 11912.
[43] Patents 898, 8254, 9518.

Specifications exist for our entire sample of patents and provide a great deal of information on a given innovation, the novel components, and the use for which it was intended. The following specifications are representative of the entire sample and are particularly revealing. The first patent, number 649, was that granted in 1749 to Thomas Frye, a painter from Essex who worked at the Bow porcelain factory and developed 'a new method of making a certain ware'. Emphasis has been added to several vague terms and phrases.

Patent 649: Thomas Frye – a new method of making a certain ware

(a)

FRYE.
17th Nov. 1749

649. A grant unto Thomas Frye, of the parish of West Ham, in the county of Essex, painter, of his new invented method of making a certain ware.

(b)

> FRYE, THOMAS.- "New method of making a certain ware, which is not inferior in beauty and fineness, and is rather superior in strength, than the earthenware that is brought from the East Indies, and is commonly known by the name of china, japan, or porcelain ware. Animals, vegetables, and fossils, by calcining, grinding, and washing, are said to produce an insoluble matter named virgin earth, but come, in greater quantities than others, as all animal substances, all fossils of the calcareous kind, such as chalk, limestone, &c,; *take, therefore, any of these classes*, calcine it, grind and wash it in many waters, and reiterate the process twice more, when the ashes or virgin earth will be fit for use. These ashes are mixed *in certain proportions* with flint, white pebble, or clear sand, and with water made into balls or bricks, highly burned, & ground fine, and mixed with a certain proportion of pipe clay; it is thrown on the wheel, & when finished, dried, burned, and painted with smalt or zaffre, when it is ready to be glazed with a glaze made first by making a glass with salt petre, red lead and sand flint *or other white stones in certain proportions*, grinding it up well, and mixing it with a *certain proportion* of white lead, adding a *small proportion* of smalt to clear the colour. After dipping and drying the articles are put in cases, and *burned with wood*, till the surface of the ware is clear and shining.[44]

This patent specification, which was the second patent held by Frye for porcelain ware, is particularly interesting as it is rather vague in its detail. It seems almost any combination of many ingredients will render 'a certain ware' purported to be

[44] Woodcroft, *Patents for Inventions,* 7; *Titles of Patents,* 121.

English porcelain. No amount of tacit understanding or experience in pottery production would enable anyone to accurately decipher the recipe. There are so many instances of 'certain proportions' or 'quantities' that it is unclear exactly what the innovation is. This is a far cry from the 'reliable, transparent and definitive statements' specifications were officially required to provide.[45] Frye's motives for taking out his solo patent are difficult to determine with any certainty, and the ambiguity of the specification, at a time when patent specifications were beginning to be scrutinised more closely, is at odds with an innovator who hoped to be able to successfully legally enforce a patent.[46] Here we have an interesting example of a patent being used to protect knowledge which had in all likelihood not been articulated fully even in the head of Frye himself. This was most likely a deliberate attempt to obscure any detail of the process on the part of Bow porcelain factory, with the true purpose of the patent to grant protection over the use of and experimentation with the numerous materials listed.[47] This theory finds support in Frye's first patent, No. 610 applied for 6th December 1744 and jointly held with Edward Heylin listed as a merchant from Middlesex, which was also vague and obscure in detail.[48] At the turn of the twentieth century, Burton produced a history of porcelain development in England and set about testing Heylin and Frye's patent through 'exhaustive experiments' with bodies and raw materials. Despite his efforts he was unable to produce anything equating to porcelain using the patent specification and was highly disparaging of the pair's patent: 'Not only were the proportions of Heylin and Frye entirely wrong, but the frit [an ingredient crucial for the consistency of the porcelain body] was useless for its supposed purpose.'[49]

The second patent was granted to Josiah Wedgwood in 1769 for his famous black basalt ware and was the only patent held by the Master Potter.

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[45] Bottomley, *The British Patent System*, 181.
[46] I am grateful for the comments of an anonymous reviewer for raising this question of motives in this way.
[47] *A History of the County of Middlesex,* 146.
[48] Woodcroft, *Titles of Patents,* 114; *Patents for Inventions,* 6.
[49] Burton, *A History and Description of English Porcelain*, 7-11.

Patent 939: Josiah Wedgwood (I) – his invention for the purpose of ornamenting

(a)

WEDGWOOD. 16th Nov. 1769	**939**. A grant unto Josiah Wedgwood, of Burslem, in the county of Stafford, potter, of his invention for the purpose of ornamenting of earthen and porcelaine ware an encaustic gold bronze, together with the peculiar species of encaustic painting in various colours.

(b)

> WEDGWOOD, JOSIAH.- "The purpose of ornamenting earthen and porcelaine ware with an encaustic gold bronze, together with a peculiar species of encaustic painting in various colours in imitation of the antient Etruscan and Roman earthenware. In carrying out this invention, the patentee first prepares ten ingredients, among which is bronze powder, some of these are one chemical substance, whilst others are composed mostly of several chemical substances in certain proportions, and generally calcined together. The substances are Ayoree, a white earth in North America, gold, aqua regia, copper, oxide of antimony, tin ashes (oxide of tin), white and red lead, smalts, borax, nitre, copperas, flint, manganese and zaffre. By mixing these ingredients with the exception of the bronze power, in different proportions, he obtains seven colours, which he names as follows: - Red, orange, dry black, white, green, blue, yellow, and he produces another colour, which he names shineing black, by mixing some of these ingredients and one of the colours, namely, the green.
> In applying the bronze powder, grind some of it in oil of turpentine, and apply this by sponge or pencil to the vessels finished, ready for burning, but not quite dry, polish it; heat the ware as high as is necessary for it; afterwards burnish the bronze. Applying the bronze after the ware is fired bisket, make a mixture in certain proportions of white lead and calcined ground flint, grind them well together; apply this thin with a sponge or brush, flux it, then apply upon it the bronze as before directed. Shining black (and other colours) upon red vessels, antique Etruscan vases. These colors are ground with oil of turpentine before applying them to the vessels, and are proceeded with as in the first application of the bronze powder.[50]

A full and complete specification was printed in the *Repertory of patent inventions* published in 1797.[51] This specification contained weights and measurements and a description of the process required although it is still far from a 'how-to' guide to re-creating the encaustic decoration. Aside from being an extremely complex process, and one which was very difficult to get to work, the patent reveals the

[50] Woodcroft, *Titles of Patents,* 169; *Patents for Inventions,* 9.
[51] *The Repertory of Arts,* Vol. 7, 309-14.

extent of Wedgwood's knowledge of minerals and chemical processes. The knowledge underpinning this patent was complex scientifically derived knowledge combined with experiential knowledge gained through extensive experimentation.

The third patent examined is for a decorative gold lustre recipe and was granted to Godwin Embrey, a North Staffordshire potter, in April 1835.[52] There was considerable scepticism at the time concerning the degree of novelty in this innovation, and indeed whether the specification provided any new information or knowledge.[53] The *London Journal* provides an account of the specification which is useful here:

> *This invention appears to us to possess but a very slight degree of novelty, the whole of the invention consisting in adding a little gum to the ordinary composition in use among potters, and known by the name of gold lustre […] but for what purpose this ingredient is added, the specification does not inform us.*[54]

This may have been an attempt on Embrey's part to capitalise on an existing set of techniques and knowledge which were already 'commonly used' in the industry. In this instance, Embrey used the patent as a way of appropriating existing rather than newly created knowledge.

The final two patent specifications to be examined highlight the differences between patents pertaining to or containing valuable scientific knowledge, typically difficult to reverse-engineer, and those later patents granted during the 1830s and 1840s for mechanical innovations in which component pieces and mechanisms were more easily discernible. The first was held by John Ridgway, a celebrated North Staffordshire potter who, along with George Wall, was involved in early attempts to mechanise pottery production during the 1840s. Between them, the pair took out five patents in the decade including one for a flatware machine known as a *Jolly* which was installed at Mason's manufactory in North

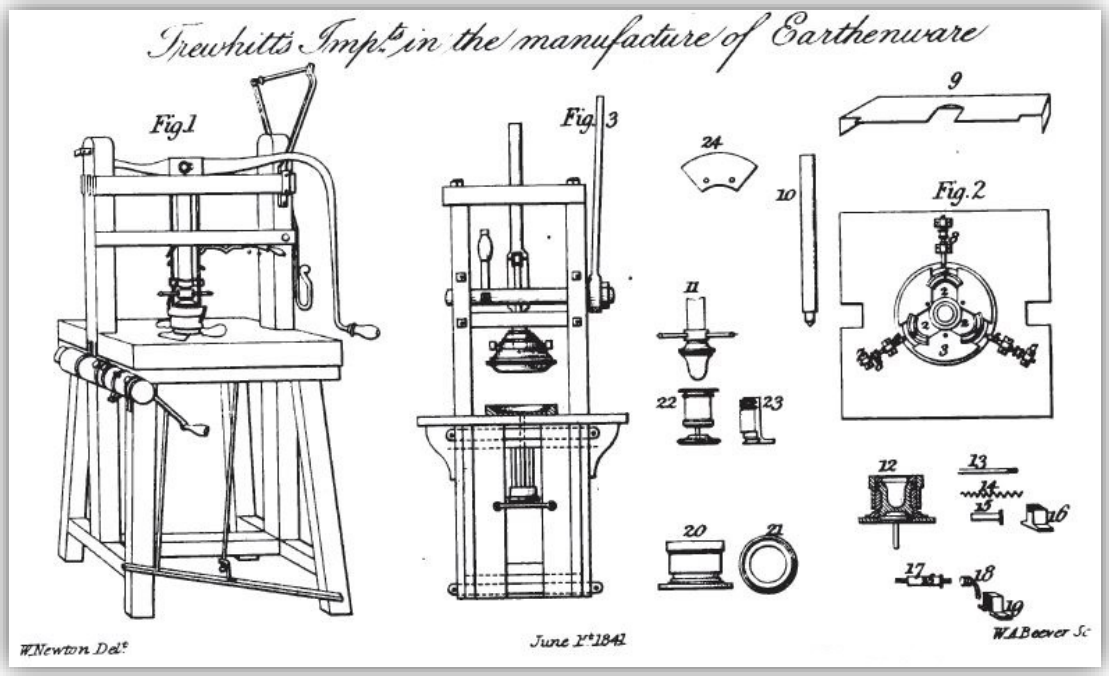
[52] Woodcroft, *Patents for Inventions,* 29.
[53] *The London Journal of Arts*, Vol. 13, 22-3.
[54] *Ibid.,* 22.

Staffordshire in November 1844. Early attempts by the pair were largely unsuccessful and it was not until the 1870s that this type of machine was in general usage.[55] Ridgway's patent was relatively simple to understand and was clearly designed to be as detailed as possible with some passages accompanied with qualifications such as 'this term being well understood by potters and persons conversant with such manufacture'.[56]

This difference in approach to the specification is even more pronounced when we examine the patent of Henry Trewhitt, a Gentleman from Newcastle-on-Tyne which was granted in December 1839.[57] The full specification is extremely detailed and accompanied by numerous diagrams, such as those shown in Figure 7. Each component part was referred to in the specification including the material they should ideally be formed of (copper, iron etc.). The process of each mechanism was described along with the function of each part. From a technical perspective, there is no reason to believe that someone with experience of machine making would not be able to reproduce the machine to a reasonable degree of accuracy thus allowing for tinkering and improvement. Whilst this patent undoubtedly revealed a great deal about the machine, the specification itself is purely technical and does not contain any additional insight or information which could not be gleaned by viewing the machine in person.[58]

[55] Lamb, 'The Press', 1; Warburton, *The History of Trade Union Organisation,* 191-2; Burchill and Ross, *A History,* 154.
[56] *The Repertory of Patent Inventions,* Vol. 17, 280-281.
[57] Patent no. 8295, Dec. 4 1839: *Titles of Patents,* 1095.
[58] *The London Journal of Arts*, Vol. 18, 297-300.

Figure 7: Technical Drawings for Henry Trewhitt's Patent: granted 4 December, 1839[59]



Patent specifications in the English pottery industry can thus be divided into two types based on their knowledge components. The first type, the detailed patent specification, offered potential readers a large amount of information and, in the case of those such as Trewhitt's, almost certainly offered enough for a reader with a limited degree of experience or knowledge to reconstruct or replicate the invention. The knowledge disseminated here was mechanical knowledge, articulable and explicated by its embodiment in a tangible object such a mechanical lever and therefore more easily defensible through the patent system.

The second type of patent, the vague, abstract and sometimes incomprehensible patent, offered little valuable information to a reader and often, though not always, only signified that some sort of innovation had occurred. The knowledge in those patents which did support an innovation was clearly extremely valuable and specifications revealed as little useful or actionable information as possible to readers and potential competitors. A degree of the scientific and chemical knowledge hinted at in these patent specifications was explicable, in the sense

[59] *Ibid,* plate XII

that quantities and procedures for recipes *could* be written down in considerable detail (as in Wedgwood's patent and the discussion below). This was largely not the case however, and much of the valuable and useful knowledge that could be articulated was kept secret, either in the head or experiment books of the Master Potter. The other component of this second type of knowledge was the tacit element that could not be articulated easily and is best captured by Polanyi's dictum that 'we know more than we can tell'.[60] No amount of detail or written text could disseminate the skills and experience required to develop and make a new design, shape, pattern or style.

Registered designs or copyright protection in the pottery industry did not exist in England until the 1840s. Whilst other trades such as printmakers, artists, and cotton textile printers were early beneficiaries of the 1735 *Hogarth's Act*, and the Copyright Act of 1787, earthenware goods had no such institutional protection until the introduction of the Copyright of Designs Act in 1839.[61] MacLeod argues that because this legal framework was absent before the middle of the nineteenth century, the tension around what constituted a novel invention 'was at its most acute', thus, the majority of potters refrained from patenting in acknowledgement of this issue.[62] Sherman and Bentley provide a finer analysis and point to a distinction, although short-lived, during the nineteenth century between different areas of intellectual property; copyright on the one hand and patents on the other. Copyright was seen as the domain for art, or designs, whereas patents were upheld as examples of 'industrial property' and generally held in higher regard; this opposition perpetuated as the nineteenth century progressed.[63] In short, outside of copyright law, protection for designs, such as those crucial to the pottery industry, sat somewhat uneasily alongside the technical, industrial protection provided by patents. This could help to explain the consistently low level of patenting in the pottery industry until the 1840s.

[60] Polanyi, *The Tacit Dimension,* 4, 10.
[61] Macleod, *Inventing,* 67.
[62] *Ibid.*
[63] Sherman and Bently, *The Making of Modern Intellectual Property Law*, 161-62.

However, given the importance of tacit and uncodified knowledge in pottery production, the difficulty in reverse engineering such knowledge, and the lack of widespread mechanical penetration into the industry, any explanation based solely on the legislative environment is not sufficient. If we accept the argument put forward by Moser that the level and type of knowledge in an industry largely determines the propensity to patent and the degree of innovation outside of the patent system, then we must engage further with the innovations themselves and evidence other than patents.[64]

4. Knowledge and innovation outside the patent system

Exhibition records offer an indicator of innovation in an industry regardless of whether they were patented or not. As Moser notes, a crucial weakness in exhibition data in general is that innovations which were easy to replicate or copy may be underreported if we assume that innovators may not wish to divulge their secrets.[65] With earthenware exhibits this is not as serious an issue as the innovation or key component of potters' wares, the composition of the body, was inherently difficult if not impossible to determine once at the fired stage. The fact that most the pottery exhibits displayed at the Crystal Palace were finished wares and were freely open to examination by any paying visitor suggests that potters were not concerned that their trade secrets would be revealed or discovered in this way.[66] In our case, official reports of exhibitions and fairs are useful as they reveal the perception of novelty, innovation and success in the pottery industry. Official reports relating to the Great Exhibition of 1851 contain detailed and remarkably balanced accounts for each of the thirty exhibition classes, in addition to strict industry-specific criteria upon which international prize juries must base their decisions.[67]

[64] Moser, 'Why don't inventors patent?', 3.
[65] Moser, 'How do patent laws', 1219.
[66] *Great Exhibition,* Vol. 2, 709-728
[67] *First Report of the Commissioners*; *Reports by the Juries.*

Pottery prizes and awards at the Crystal Palace were given for 'Important inventions and discoveries, or regularity combined with excellence of design; novel application of known discoveries; great utility combined with economy and beauty; excellence of workmanship and quality.'[68] The criteria of novelty, invention and innovation were exacting and, overall, applied relatively evenly. Given this, the awarding of a prize may be taken as a proxy, albeit a very rough one, for international conceptions of what constituted leading quality, invention and innovation in the pottery industry by the middle of the nineteenth century.

Based on the reports the key reasons for the granting of each prize indicate that novelty, unsurprisingly, played a key role. Utility and practicality were also important with several potters rewarded for modifying existing products through the addition of qualities and properties that enabled them to be more useful for a wider range of tasks, especially those involving chemicals. Quality was almost never the principle or sole reason for an award and should not be a surprise given the prestige of the Great Exhibition and the challenging selection process.[69]

The award citations for 1851 suggest that novelty and innovation relied on knowledge-intensive efforts in the scientific and chemical based processes of glazes, colours and body composition. The knowledge required to succeed in these aspects of production was protected by the virtue that the end-products had undergone a series of irreversible chemical reactions during the firing processes. This rendered the innovation somewhat elusive to the untrained eye, and very difficult to reverse-engineer even for an experienced practitioner. If Moser's analysis for the second half of the nineteenth century holds for our period, this may impact on the strategies employed by producers to appropriate the returns to their innovations. The chemical-based innovations deemed to be the finest required high levels of scientific knowledge (not necessarily formal knowledge) and could thus be protected outside of the patent system through, for example, secrecy.

[68] *First Report of the Commissioners*, 202.
[69] *Reports by the Juries*, 1184; Moser and Nicholas, 'Prizes', 765.

There were of course other ways in which producers could achieve recognition and remuneration for their innovations before the proliferation of World Fairs after 1851. In 1822 Job Meigh was awarded a 'Large Gold Medal' by *The Society of Arts* for his production of a new lead-free glaze.[70] The details of this case were the subject of much comment and debate in trade literature of the time. An anonymous inquirer wrote to *Mechanics' Magazine* in May 1824 referring to an unknown gentleman (Meigh) who had been awarded a Medal for the discovery of a lead-free glaze. He suggested:

> *'If that gentleman does not wish to monopolize to himself the advantages which may arise from his discovery, he would do well to give it publicity through the medium of the Mechanics' Magazine.'*[71]

Whilst this is suggestive of the notion that certain ideas and innovations were discovered but not appropriated by their inventors, perhaps in some altruistic manner, the response of a second anonymous contributor, 'G. C.', points toward a more logical explanation:

> *'Specimens of the ware […] and of the glaze itself, as well as of the ingredients of which it is composed, are placed in the Repository of the Society [of Arts]. See Volume 40, of the Transactions of the Society of Arts, in which is detailed the ingredients of the above glaze, and also an improved composition for the ware itself.'*[72]

The knowledge and secrets which could have been appropriated by Meigh himself were published, although in a very rudimentary format, and thus made publicly available.[73] A patent may have allowed Meigh to appropriate some of the gains from this discovery although in the event he was bound by the decree of the Society who published the information: 'all articles rewarded by the SOCIETY, shall be freely given up to the public, to be made or manufactured by any person whatever.'[74]

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[70] *Mechanics' Magazine*, Sat 8th May, 1824, 142.
[71] *Mechanics' Magazine,* Sat 31st Jan, 1824, 366.
[72] *Mechanics' Magazine,* Sat 8th May, 1824, 142.
[73] A somewhat vague and simplistic recipe is printed in the source: *Transactions of the Society,* Vol. 40, 46. *Mechanics' Magazine* was targeted at the 'autonomous practical artisan', and there is strong evidence to suggest that it had a wide readership among the artisan class outside of London; Marsden, 'Carriages', 243-254.
[74] *Transactions of the Society,* Vol. 40, vii-ix.

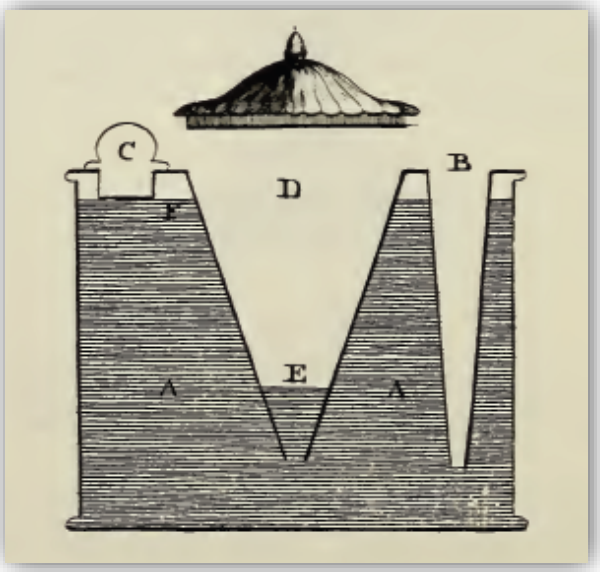
Sales catalogues are an excellent supplementary source as they are detailed and often illustrated, although very few from the eighteenth century survive. Wedgwood's innovations in marketing and sales techniques are well known and researched.[75] Examination of a sales catalogues from the 1780s gives us an indication of what one of the most successful and pioneering potters saw as novel and innovative.[76] The meticulously organised catalogue provides commentaries for each class of ware produced at Etruria, the majority of which came with a qualification of excellence: 'no cameos […] of equal beauty, magnitude and durability […] have ever before been offered to the public'; and perhaps the most self-elevating, 'persons of the most refined taste have acknowledged this to be a higher and more perfect species of painting than was known to the world before the date of this invention.'[77] This, of course, is to be expected. Wedgwood went to considerable efforts to illuminate the originality and innovation of a few choice pieces above all others: three pages and an illustration are reserved for Wedgwood's 'Etruscan' wares of a black basalt body and encaustic decoration, a style he pioneered during the late 1760s and had perfected by the 1770s.[78] This represented the pinnacle of experimentation, art, taste and imitation: the 'new species of encaustic colour [was] durable […], entirely free from the varnished or glassy aspect' of previous imitations, and above all, consistent. 'The colours never spread in the fire or run out of drawing.'[79] Although by the time of the publication of the catalogue Wedgwood had attained a degree of efficiency in production of Etruscan wares, the potter was losing around 85 per cent of production in the firing stages in the late 1760s and thus had to charge very high prices.[80] Not only did the innovation provide an entirely new product and solved imperfections and inconsistencies, but this encaustic decoration had the compound effect of reducing the skill level required to imitate objects of classical antiquity. The method allowed

[75] see: McKendrick, 'Josiah Wedgwood', 408-33; 'Josiah Wedgwood and Thomas Bentley', 1-33; Blaszczyk, *Imagining Consumers*.
[76] *The Wedgwood Catalogue.*
[77] *The Wedgwood Catalogue,* 31, 64, 66.
[78] This encaustic style of decoration was, incidentally, the only innovation for which the potter held a patent. *Ibid.,* 62-5; Reilly, *Josiah Wedgwood,* 79-81.
[79] *The Wedgwood Catalogue,* 64.
[80] Reilly, *Josiah Wedgwood*, 79.

'moderately skilled painters' to achieve high levels of quality and likeness.[81] Wedgwood was careful not to reveal too much useful information regarding the composition or production process for his Etruscan ware, publicising just enough to signal that this was both extremely difficult and innovative whilst the all-important recipe and specific knowledge remained elusive.

Wedgwood also diversified into developing new uses for earthenware. He was keen to promote his innovative new black basalt bodied ink-stand which 'is neither corroded by the ink, nor absorbs it, nor injures its colour, as the metals used for these purposes do'. The entry was accompanied by an annotated technical drawing, shown in Figure 8.

Figure 8: Wedgwood's black basalt ink-stand, advertised in his product catalogue of 1787[82]



The illustration and description clearly reveal the mechanical and design properties of the ink-stand. Moreover, these features could be examined in detail and 'reverse-engineered' or imitated through purchase. This was not patented however and the chemical secrets of the composition of the black basalt body, the most crucial innovation in this product, remained intangible. Once more,

[81] *Ibid.*
[82] *The Wedgwood Catalogue,* 67.

Wedgwood was selective in the knowledge he revealed, publicising only that which could be easily attained by fellow manufacturers. Here then, we have examples of two different types of knowledge related to innovation in the pottery industry. The first is that scientific knowledge which allowed and produced innovations resulting in entirely new product ranges, such as Wedgwood's Etruscan ware, which was obtained through much experimentation, and which was protected by its very nature and the ability to keep it secret. The second type of knowledge relates to the visual and tangible elements of design and construction and which is not rooted in scientific understanding. This type of knowledge, as seen in the Crystal Palace exhibits, can be freely publicised, advertised and shared. Clearly there were decisions to be made here between the disclosure of crucial knowledge or secrets, and the advertisement and dissemination of the product.

An article on glazing in *Mechanics' Magazine* from 1825 offered a recipe and instructions for a new lead-free glaze which had been developed by Mr Rochinski, a potter in Berlin. Whilst the recipe was relatively straightforward in terms of quantities, a certain amount of prerequisite knowledge or experience was required to get the consistency right: 'a mixture fit to be readily applied on the earthenware, and to cover it equally all over'.[83] The comments made by Robert Campbell in 1747 were still pertinent almost a century later when we consider a further article in *Mechanics' Magazine* describing a 'Lecture on Pottery' which was given by a Mr. Cowper at the Royal Institution in March 1839.[84] The content and delivery of his lecture are indicative of the 'cognitive limitations' associated with the communication and transfer of technical and tacit knowledge in the pre- and early-modern period. [85] Although Mr Cowper was a Master Potter, in order to demonstrate skills and techniques even at the most basic level he required a live demonstration by a potter working at a wheel.[86] Following Polanyi's dictum once more, the type of skills required for pottery or any other intensive craft based

[83] *Mechanics' Magazine*, Sat 5th November, 1825, 46.
[84] *Mechanics' Magazine,* Sat 6th April, 1839, 14-15.
[85] Epstein, 'Property Rights', 382.
[86] *Mechanics' Magazine,* Sat 6th April, 1839, 15.

production rely on the craftsman's 'awareness of a combination of muscular acts for attending to the performance of a skill.'[87] Cowper's lecture thus demonstrates the problems that can arise in the transfer of certain types of knowledge, especially when we consider that the way in which we try to teach or articulate a skill or piece of knowledge may be in a very different form to when we actually do it ourselves.[88] We have also seen examples of the tensions Collins highlights between knowledge which 'is not' explicated on the one hand, and knowledge which 'cannot' be explicated on the other.[89]

A fascinating exchange in *Mechanics' Magazine* highlights the importance of secret, scientifically focused knowledge. In March 1833, a contributor writing under the alias of 'Friar Bacon of Hulton Abbey' responded to requests from readers for information on pottery glazes.[90] Under the title 'Secrets in Pottery', Friar Bacon submitted 108 recipes with 'reason to believe that they include nearly all of those in any repute' (Figure 9). They included recipes for bodies and glazes used in the manufactories of Meigh, Spode, Davenport, Wedgwood, Clowes, Yates and Moore, to name a few. These were far more detailed than those listed in patent specifications or other literature and were each composed of 100 parts which were then apportioned for each ingredient.

To illustrate the level of disclosure that the publication of these secrets provided, comparisons with patent specifications that referred to recipes can be made. John and William Turner, who operated a pottery in Lane-End, Staffordshire, were granted a patent in 1800 for a new method of manufacturing porcelain and earthenware that involved the introduction of a new substance that was found in Staffordshire coal mines known as 'Tabberners Mine Rock' or 'Little Mine Rock'.[91] The specification is relatively short and is vague when describing the characteristics of the new substance:

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[87] Polanyi, *The Tacit Dimension*, 4, 10.
[88] Collins, *Artificial Experts,* 85.
[89] Collins, *Tacit and Explicit,* 1-4.
[90] *Mechanics' Magazine,* 31 March, 1833, p. 434.
[91] *The Repertory of Arts and Manufactures* (Vol. 12, 1800), p. 299.

> *'This stone, or rock substance […] between a hard marle and an iron-stone rock […] is an ash or greyish colour, but, when dry, becomes whiter; and, if bunt in a potter's oven, with the degree of heat generally used in burning their wares, becomes very white, without any appearance of fusion.'.*[92]

The patent then went on to blur the description of the substance even further:

> *'Any stone or substance corresponding with this description, or of a similar quality, wherever found, and whether known by the name or names of the Tabberners Mine Rock, Little Mine Rock, and New Rock, or by any other name or names, is the material for which we have applied for the said letters patent, and which we mean to appropriate to our own use, in the manufacturing of porcelain and earthen ware.'*[93]

This suggests the patentees were trying to widen the scope of their patent with this description, and it is clear that they were keen to gain a return on their discovery. When the specification turns to details of the recipe and preparation of the mixture far less is revealed than in Friar Bacon's recipes. John and William Turner referred to breaking the body down into parts although they were far from precise in their description. Again, the proportions are loose and flexible enough to capture a wider range of body compositions.

> *'The proportions we think the best, are from six to ten parts of the said new material to one part of the flint or siliceous earth. But, although we have described what we consider as the best proportions using the said new material, in the manufacturing of porcelain and earthen-ware, it is expressly to be understood, that we do not mean absolutely to confine it to these proportions, inasmuch as the proportions must necessarily vary, according to the particular article to be manufactured.'*[94]

A similar style of patenting was continued by William Hodge who was granted a patent for the introduction of a new substance to earthenware production known as hornstone porphyry or 'elvan'. The specification was vague when it came to any details of the recipe that was being employed and the materials being used: 'I find that a large or a small proportion of elvan may be employed, and the effect in the ware produced will be in relation to the relative proportions; and therefore the

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[92] *Ibid.,* p. 300
[93] *Ibid.*
[94] *Ibid.,* pp. 301-2.

workman will use his judgment in the quantity he employs, according to the effect he desires to obtain.'[95] Here, then, the onus was placed on the person interpreting the patent to get the correct proportions of materials. Just as the Turner's sought to appropriate the use of 'Tabberners Mine Rock', so too Hodge sought to limit the use of elvan.

There were several other instances of patents for new recipes for bodies and glazes that followed the same pattern; the restricted detail when it came to being able to reproduce the innovation, and the loose and flexible definition of the materials used in order to capture a greater range. Patents were granted for John White in 1809, Joseph Gibbs in 1841 and George Skinner and John Whalley in 1845 which all referred to recipes and new compositions for the bodies of wares.[96] All these patents adopted a guarded style and sought to reveal the minimum amount of useful knowledge. The practice of patenting recipes was clear in the pottery industry.

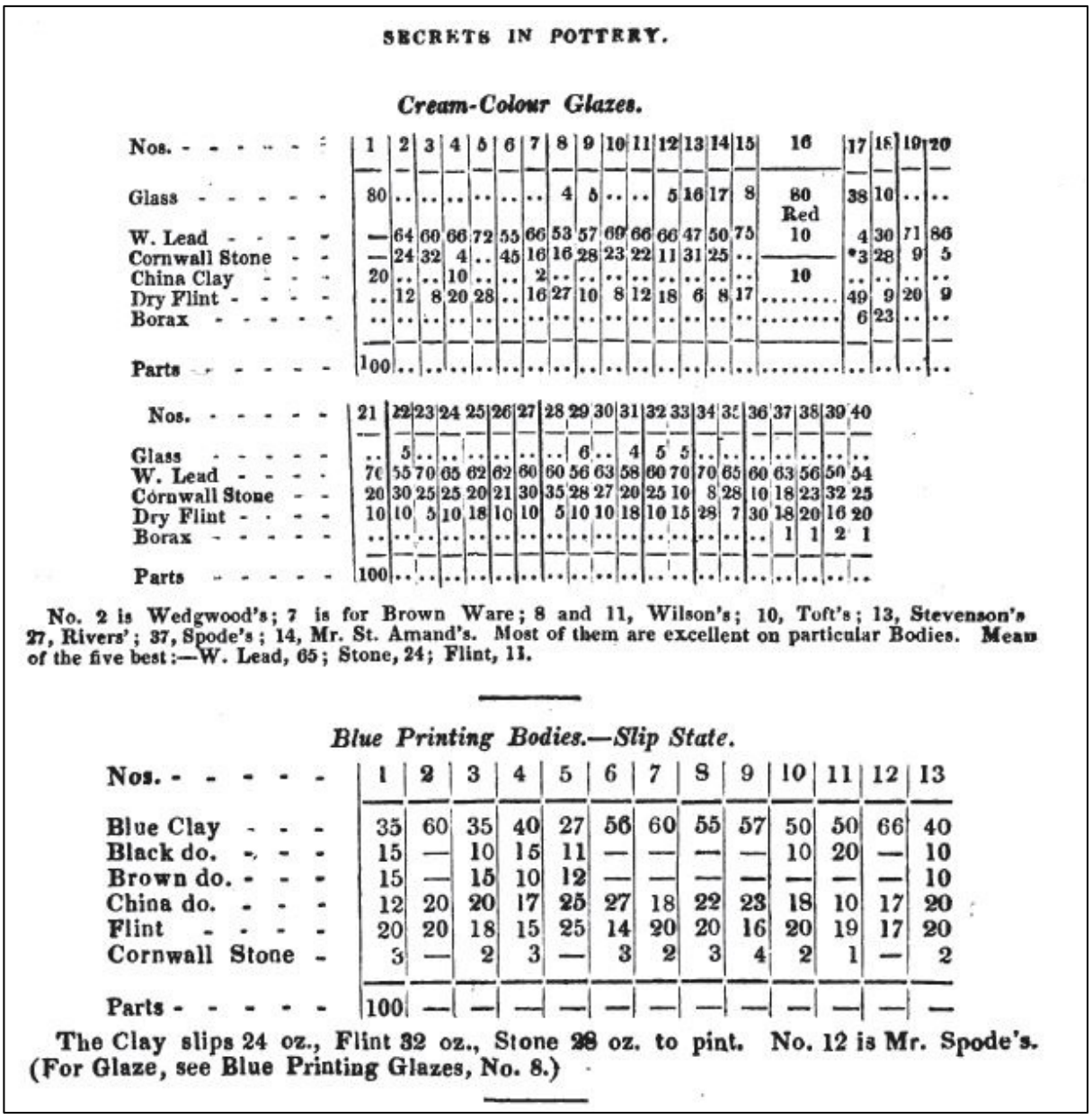
By contrast, the recipes provided by Friar Bacon were far more useful in the details that they revealed. Whereas the patents did not reveal proportions or quantities, Bacon's recipes were broken down into parts and annotated. Many of the recipes were accompanied by notes which included: 'J. Clowes says, this is a much better Glaze' and 'No. 1 is a good body, much approved in the American Market; requires a hard fire'.[97] The fact that the contributor was writing under an alias draws attention to the desire to remain unknown, perhaps due to the fact this is one of the only documented open publications of pottery recipes found which in itself, and along with the title suggests, that these were tightly held 'secrets'.

[95] *The Repertory of Patent Inventions* (Vol. 19, 1852), p. 353
[96] The specifications for these patents are printed in the following sources in the same order as in the text: *The Repertory of Arts, Manufactures, and Agriculture* (Vol. 16, 1810), p. 260; *The Inventors' Advocate, and Journal of Industry* (Vol. 1, 1841), p. 309; *The Patent Journal, and Inventors' Magazine* (Vol. 1, 1846), p. 136.
[97] *Mechanics' Magazine,* 31 March, 1833, p. 433.

Friar Bacon's identity remains a mystery, although there are several possible scenarios based on conjecture. The choice of moniker is an interesting one. It could be a reference to Roger Bacon (c.1214-c.1292), the English natural philosopher and Franciscan Friar with an interest and skill in optics and mathematics.[98] It is possible that the individual behind the name was a particularly well-travelled potter who had spent time working at many different workshops across the district. This is entirely plausible given the high turnover of firms and likely exposure to recipes if he worked in the dipping house for example. A less plausible alternative is that Friar Bacon's contributions are the work of a disgruntled employee who felt the need to publicise the secrets of his past employers. Although for this to be the case he must have held a grudge against a large number of potters. It is, also possible that Friar Bacon was an outsider to the district, someone who had managed to procure detailed recipes by means of subterfuge. However, the motives are not clear as one may assume that an outsider to the industry with access to such knowledge may try to sell the information privately, rather than publish it publicly and freely.

[98] George Molland, 'Bacon, Roger (c.1214–1292?)', *Oxford Dictionary of National Biography*, (Oxford University Press: Oxford, 2004) online at http://www.oxforddnb.com/view/article/1008, [accessed 12 Sept 2017].

Figure 9: 'Secrets in Pottery' compiled by Friar Bacon of Hulton Abbey, printed in Mechanics Magazine, 31 March 1833



SECRETS IN POTTERY.

Cream-Colour Glazes.

Nos.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Glass	80	..	..	..	..	..	..	4	5	..	..	5	16	17	8	80 Red	38	10	..	..
W. Lead	—	64	60	66	72	55	66	53	57	69	66	66	47	50	75	10	4	30	71	86
Cornwall Stone	—	24	32	4	..	45	16	16	28	23	22	11	31	25	..	———	*3	28	9	5
China Clay	20	..	..	10	..	..	2	..	..	..	..	..	..	..	..	10	..	..	..	..
Dry Flint	..	12	8	20	28	..	16	27	10	8	12	18	6	8	17	.....	49	9	20	9
Borax	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	.....	6	23	..	..
Parts	100	..	..	..	..	..	..	..	..	..	..	..	..	..	..	.....	..	..	..	..

Nos.	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
Glass	..	5	..	..	..	..	..	..	6	..	4	5	5	..	..	..	..	..	..	..
W. Lead	70	55	70	65	62	62	60	60	56	63	58	60	70	70	65	60	63	56	50	54
Cornwall Stone	20	30	25	25	20	21	30	35	28	27	20	25	10	8	28	10	18	23	32	25
Dry Flint	10	10	5	10	18	10	10	5	10	10	18	10	15	28	7	30	18	20	16	20
Borax	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1	1	2	1
Parts	100	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..

No. 2 is Wedgwood's; 7 is for Brown Ware; 8 and 11, Wilson's; 10, Toft's; 13, Stevenson's 27, Rivers'; 37, Spode's; 14, Mr. St. Amand's. Most of them are excellent on particular Bodies. Mean of the five best:—W. Lead, 65; Stone, 24; Flint, 11.

Blue Printing Bodies.—Slip State.

Nos.	1	2	3	4	5	6	7	8	9	10	11	12	13
Blue Clay	35	60	35	40	27	56	60	55	57	50	50	66	40
Black do.	15	—	10	15	11	—	—	—	—	10	20	—	10
Brown do.	15	—	15	10	12	—	—	—	—	—	—	—	10
China do.	12	20	20	17	25	27	18	22	23	18	10	17	20
Flint	20	20	18	15	25	14	20	20	16	20	19	17	20
Cornwall Stone	3	—	2	3	—	3	2	3	4	2	1	—	2
Parts	100	—	—	—	—	—	—	—	—	—	—	—	—

The Clay slips 24 oz., Flint 32 oz., Stone 28 oz. to pint. No. 12 is Mr. Spode's. (For Glaze, see Blue Printing Glazes, No. 8.)

Source: *Mechanics' Magazine,* 31 March, 1833, p. 434.

In June 1833, several months after the publication of these original recipes, a 'constant reader' from Newcastle-under-Lyme in the Potteries raised their concern over the publication of secrets. In a short statement the reader noted that the Friar's actions had 'put all in commotion'.[99] Objections to the disclosure were raised although the reader went on to express his pleasure in receiving the

[99] *Mechanics' Magazine,* 29 June, 1833, p. 223.

information and requested further glaze and body recipes. This objection tells us two things that both point to the reliability of the recipes. Firstly, the fact that an objection was made is an indication that the 'constant reader' was concerned about secret knowledge being leaked into the wider community. If the recipes were bogus or ineffective, then it is unlikely that they would have caused such a stir. Secondly, the reader ended the objection on a positive note and placed a more specific request for 'chalk and china bodies and glazes.'[100] Again, it is safe to assume that if the original recipes were not effective or trusted, further requests would not be made. Clearly, then, whilst there were some moral or ethical issues raised, the pragmatic reader recognised the importance of the knowledge that was published. The *Magazine* obliged the reader and continued the somewhat obvious deception and intrigue but explaining the delay in publication: 'though [the Friar's] knowledge is modern, [he] writes in so ancient and crabbed a fashion […] it takes more time than we have been recently able to command, to furnish the printer with an intelligible transcript of his manuscript.'[101] Dutifully, on 13th July the *Magazine* published a further 31 recipes provided by the Friar under the title 'More Pottery Secrets'. These had the same level of detail and were in turn followed by 36 more recipes a week later.[102] Unfortunately the trail of Friar Bacon runs dry and there are no further references to this episode. The saga ended on 20th July 1833, but not without 175 detailed recipes being published. The local newspaper for the region at the time, the *Staffordshire Advertiser*, made no mention of the leak, or of any secrets in the pottery industry save one: the advertisement shown in Figure 10.

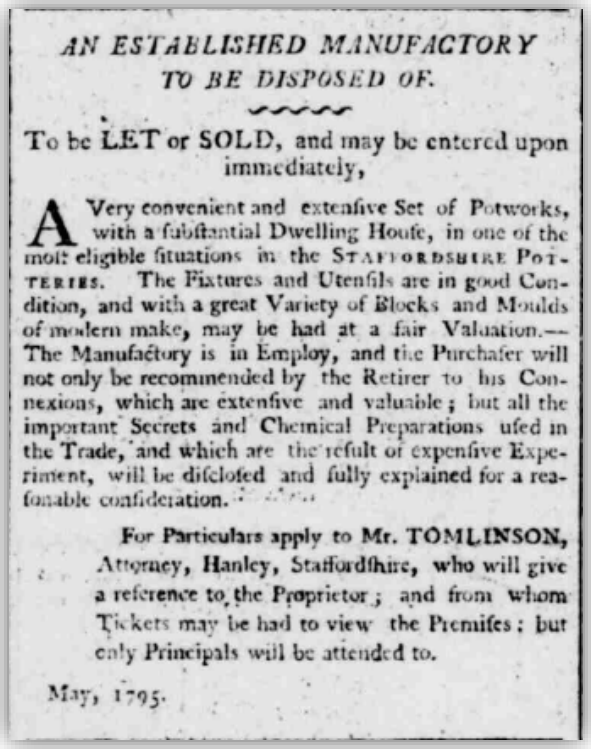
5. Secrets and the nature of knowledge in the pottery industry

The advertisement shown in Figure 10 for the sale or letting of a pottery manufactory was placed by an anonymous proprietor in the *Staffordshire Advertiser* for several weeks over May and June 1795. It is suggestive of several

[100] *Ibid.*
[101] *Ibid.*
[102] *Mechanics' Magazine,* 20 July, 1833, p. 263.

features of the English pottery industry at the time: networks and connections mattered; 'important secrets' of the trade could be acquired either through 'expensive Experiment', or purchased for a 'reasonable consideration'; producers could access an informal market for certain types of useful and reliable knowledge which were seen as providing competitive advantage in the industry. This is only known example of secrets in the pottery industry being openly offered in local newspapers for purchase between 1795 and 1851.[103]

Figure 10: Advertisement placed in Staffordshire Advertiser[104]



AN ESTABLISHED MANUFACTORY
TO BE DISPOSED OF.

To be LET or SOLD, and may be entered upon immediately,

A Very convenient and extenſive Set of Potworks, with a ſubſtantial Dwelling Houſe, in one of the moſt eligible ſituations in the STAFFORDSHIRE POTTERIES. The Fixtures and Utenſils are in good Condition, and with a great Variety of Blocks and Moulds of modern make, may be had at a fair Valuation.—The Manufactory is in Employ, and the Purchaſer will not only be recommended by the Retirer to his Connexions, which are extenſive and valuable; but all the important Secrets and Chemical Preparations uſed in the Trade, and which are the reſult of expenſive Experiment, will be diſcloſed and fully explained for a reaſonable conſideration.

For Particulars apply to Mr. TOMLINSON, Attorney, Hanley, Staffordſhire, who will give a reference to the Proprietor; and from whom Tickets may be had to view the Premiſes; but only Principals will be attended to.

May, 1795.

Of course, working in secret was a feature found in many industries, not just pottery; whilst they are scant, there are some legal cases relating to the sale of secrets from before our period in the 1680s and 1690s suggesting that this was a well-established practice in textile and chemical production at least.[105] Trading

[103] The author has conducted searches of the following local newspapers from their first publication until 1851 and found no references to secrets, trade secrets or knowledge for sale in such a manner as this advertisement. For newspapers and their publication ranges see bibliography.
[104] *Staffordshire Advertiser,* Sat 16th May, 1795
[105] Bottomley, *The British Patent System*, 204-5.

secrets, whether useful or not, was legal at the time this advertisement was placed, although there were long-standing difficulties in enforcing this practice through the Courts; the first known 'trade secrets' lawsuit was in 1682 and attempted to enforce the purchase of unspecified chemical recipes (to the value of £500), although it was ultimately unsuccessful in enforcing the decision due to the inability of the court and plaintiffs to assess the value of the secret without first knowing the secret.[106] Bottomley argues that this contributed to the confinement of legal transfer of trade secrets to medicine and chemicals on the basis that these innovations were especially suited to secret development.[107]

The first conclusion we can draw is that patenting was not a widespread strategy employed by North Staffordshire potters between 1750 and 1851. Innovating potters faced a dilemma in the tensions between the advantages of patenting an invention or idea, and the disclosure of information. In theory, the more precise and detailed a patent specification was, the easier it was for a patentee to legally defend any abuse or contestation; this also offered the potential for an innovator to close-off competition from capitalising on potential opportunities related to the innovation. In practice, this was not the case for many potters.

Josiah Wedgwood's own views on patenting were deep-rooted.[108] He had established himself in a region and industry where patenting was infrequent and his aversion was shared by his local contemporaries. Richard Champion's patent for English porcelain, which he purchased from William Cookworthy in 1774, was vehemently opposed by a considerable number of potters led in Parliament by Josiah Wedgwood. The potters objected on the grounds that it was 'injurious to the Community at large which neither the ingenious Discoverer [Cookworthy] nor Purchaser [Champion], for want perhaps of Skill and Experience in this particular Business, have been able […] to bring to any useful Degree of Perfection.'[109]

[106] Ibid.
[107] Ibid.
[108] Dutton, *The Patent System*, 26-7.
[109] *Papers Relative to Mr Champion's Application*.

Patents were opposed or encountered resistance and abuse whether they were for successful processes that were commercialised or not.

What the patent evidence shows is that aside from mechanical innovations, the natural tendency in the pottery industry was toward secrecy as a strategy. The fewer details revealed, the more ambiguous the innovation appeared to competitors, the freer the innovator was. This strategy was particularly appropriate in the pottery industry where much of the innovation was of a chemical and scientific nature until well into the nineteenth century. This finding supports MacLeod's more general statement that secrecy as a strategy was more prevalent in scientific rather than mechanical settings.[110]

North Staffordshire potters were even more resolved to make access to their prized innovations and knowledge as difficult as possible for foreign outsiders and competitors. Travel diaries written during tours of industrial regions contain further evidence of cautious potters. S. H. Spiker, on his travels through the region in 1816 wrote the following after being denied access to certain rooms in Spode's workshops: 'Mr Spode, [declared] that he had been frequently deceived by persons, who, under the pretext of seeing the manufactory, merely sought to communicate its arrangements to others'.[111]

This degree of caution towards outsiders was present in the eighteenth century too. In October 1785 Wedgwood wrote to the Secretary of the General Chamber of Manufacturers of Great Britain to voice his, and his fellow potters, concerns regarding 'three different sets of spies upon our machines and manufactures now in England'.[112] Wedgwood told of accounts from his contemporaries of foreign spies gaining access to machinery, and the inner workings of manufactories by pretending they themselves had important innovations to share.[113] Clearly there was a high degree of uncertainty and anxiety over keeping trade secrets secret.

[110] MacLeod, *Inventing*, 63.
[111] Spiker, *Travels,* 81.
[112] Letter from Josiah Wedgwood to Mr. Nicholson, 25th October 1785.
[113] *Ibid.*

The evidence discussed above also support Moser's more recent findings for the second half of the nineteenth century regarding secrecy as opposed to formal protection of intellectual property. Moser asserted that for the second half of the nineteenth-century the 'effectiveness of secrecy' was industry specific and the key determinant of the propensity to patent and that this was underpinned by the degree of scientific or technical knowledge required.[114] This paper has shown that the argument also holds for the pottery industry for 1750-1851, before Moser's period of study. This is the case because of the chemical base of many of the innovations in the pottery industry rendering them difficult to articulate, reverse engineer and make transparent. Much of the valuable knowledge could not easily be reverse-engineered and was therefore granted protection outside of the patent system. Despite Mokyr's assertion that 'any other form of protection worked even less well' than patents, North Staffordshire potters successfully employed secrecy as a strategy for success.[115]

The evidence presented here suggests that the nature of knowledge in the pottery industry was extremely important in determining the behaviour of producers with regards to articulating and disseminating knowledge. There is a wide variety of evidence for innovation in the English pottery industry during one of its most dynamic and successful periods of development. Patents offer us much in the way of quantifiable evidence, but are also extremely useful in disclosing information about the types of knowledge in the industry. Examination of additional sources reveals that the categorisation of knowledge is more complex than a simple tacit/explicit division. Firstly, there was that knowledge which was articulable and defensible in the formal sense, i.e. through patents. This included mechanical or prescriptive knowledge which was relatively easy to detect and decipher. Secondly, there was that knowledge which did not require this type of protection by virtue of the fact that it was difficult to fully articulate and transfer in the written form. Thirdly, there was knowledge which straddled the tacit and explicit distinctions.

[114] Moser, 'Why don't inventors patent?', 3, 25-26.
[115] Mokyr, *The Lever of Riches,* 250.

In its finished state as embodied in a piece of earthenware it was largely undecipherable except through extensive and expensive experimentation, with no guarantee of success or imitation.[116] However, in its articulable form in a recipe or instruction manual, this knowledge was extremely useful to those with the experience and tacit knowledge to understand and apply it. Thus, it was deemed to be of such value to a potter that it was kept secret, being revealed (somewhat cryptically) only when in its irreparably altered state. Potters thus adopted different strategies toward protecting their knowledge depending on the type of knowledge.

To address the collective invention hypothesis discussed earlier in the paper, we can draw a relatively robust conclusion. The pottery industry exhibited some, but not all, of the core features of collective invention. Innovation *was* incremental and took place largely outside of the patent system. However, the remaining criteria are not satisfied. There is no evidence of open sharing of technology, or the wilful dissemination of useful knowledge. In fact, the picture painted by the evidence suggests rather the opposite. Advances and innovations were highlighted and referenced in trade literature, patent specifications, advertisements and sales catalogues but the details and precise nature of the innovations remained secret; or, indeed, accessible only for a 'reasonable consideration' in one case. In answer to the question: does the assumption hold that a very low propensity to patent in an industry is accompanied by open knowledge sharing between producers? We can state with confidence that this is not the case in North Staffordshire during the later eighteenth and early nineteenth centuries.

[116] We are reminded here of the lengthy and expensive attempts to successfully imitate Chinese and Japanese porcelain.

References

Parliamentary Papers and Government Reports

First Report of the Commissioners for the Exhibition of 1851, London: Spicer Brothers, 1852.

Reports by the juries on the subjects in the thirty classes into which the exhibition was divided, Volume 3, London: Spicer Brothers, 1852.

Papers Relative to Mr Champion's Application to Parliament for the Extension of the Term of a Patent, London, 1775.

Tables of the Revenue, Population, Commerce, &c. of the United Kingdom and its Dependencies, Part VI, 1836, London, 1838

Newspapers, Periodicals and other Literature

Burton, William, *A History and Description of English Porcelain,* New York: A. Wessels Company, 1902.

Correspondence of Josiah Wedgwood, 1781-1794, Manchester: E. J. Morten Ltd., 1906

Great Exhibition of the Works of Industry of all Nations, 1851. Official Descriptive and Illustrated Catalogue, Vol. 2, London, 1851

Official Catalogue of the Great Exhibition of the Works of Industry of all Nations, 1851, London, 1851

Mechanics' Magazine (1823-1872)

Spiker, S. H., Travels through England, Wales & Scotland, in the Year 1816, Translated from the German, London, 1820.

Staffordshire Advertiser, (1795-1870)

Staffordshire Gazette and County Standard (1839-1850)

Staffordshire Gazette and General Advertiser (1813-14)

Staffordshire Mercury / North Staffordshire Mercury (1828-48)

The Potter's Examiner and Workman's Advocate (1843-5)

The Wedgwood Catalogue of 1787 (The Wedgwood Society of New York: New York, 1980), reprint of the original with title: [Catalogue of cameos, intaglios, medals, bas-reliefs, busts and small statues; with a general account of tablets, vases, ecritoires and other ornamental and useful articles. The whole formed in different kinds of porcelain and terra cotta, whitefly after the antique and the finest models of modern artists. By Josiah Wedgwood, F. R. S. and A. S. Potter to Her Majesty, and to His Royal Highness the Duke of York and Albany, sold at his rooms in Greek Street, Soho, London, and at his manufactory in Staffordshire]. Sixth Edition, with additions (Etruria, 1787).

Patent Sources

Intellectual Property Office, 'Patent applications filed and patents granted each year 1852 to 1915', online at: http://webarchive.nationalarchives.gov.uk/20140603093549/http://www.ipo.gov.uk/types/patent/p-about/p-whatis/p-oldnumbers/p-oldnumbers-1852.htm, accessed May 10, 2016.

The London Journal of Arts and Sciences: and Repertory of Patent Inventions, Conjoined Series, 13, London: W. Newton, 1839.
The London Journal of Arts and Sciences: and Repertory of Patent Inventions, Conjoined Series, 18, London: E. Newton, 1841.
The Repertory of Arts and Manufactures: consisting of original communications, specifications of patent inventions, and selections of useful practical papers from the Transactions of the Philosophical Societies of All Nations, &c. &c, 7, London, 1797.
The Repertory of Arts, Manufacturers and Agriculture, Second Series, XII, London: Repertory and Patent Office, 1808.
The Repertory of Patent Inventions and other Discoveries and Improvements, New Series, 17, London, 1842.
Transactions of the Society, Instituted at London, for the Encouragement of Arts, Manufactures, and Commerce 40, London, 1823.
Woodcroft, Bennet, Patents for Inventions: Abridgments of the Specifications relating to Pottery, London: Great Seal Patent Office, 1862.
---------Reference Index of Patents of Invention, From March 2, 1617 (14 James I.) to October 1, 1852 (16 Victoria), London: Great Seal Patent Office, 1862.
---------Subject-Matter Index (Made from Titles only) of Patents of Invention, From March 2, 1617 (14 James I.) to October 1, 1852 (16 Victoria), Two Volumes, London: Great Seal Patent Office, 1857.
---------Titles of Patents of Invention, Chronologically Arranged, From March 2, 1617 (14 James I.) to October 1, 1852 (16 Victoria), London: Great Seal Patent Office, 1854

Secondary Sources

Books

Berg, Maxine, *Luxury and pleasure in eighteenth-century Britain*, Oxford: Oxford University Press, 2007.
Blaszczyk, Regina Lee, *Imagining Consumers: Design and Innovation from Wedgwood to Corning*, Baltimore: Johns Hopkins University Press, 2000.
Bottomley, Sean, *The British patent system during the Industrial Revolution*, Cambridge: Cambridge University Press, 2014.
Burchill, F, and Ross, R., *A History of the Potters' Union,* Stoke-on-Trent: Ceramic & Allied Trades Union, 1977.
Collins, H. M., Artificial Experts: Social Knowledge and Intelligent Machines, Cambridge, Mass.: MIT Press, 1990.
Collins, H. M., *Tacit and Explicit Knowledge*, Chicago: University of Chicago Press, 2010.
Dutton, H. I., The patent system and inventive activity during the Industrial Revolution, 1750-1852, Manchester: Manchester University Press, 1984.
Holgate, David, *New Hall*, London: Faber and Faber, 1987.
Inkster, Ian, Science and Technology in History, An Approach to Industrial Development, Basingstoke: Macmillan, 1991.
Macleod, Christine, Inventing the Industrial Revolution: The English Patent System, 1660-1800, Cambridge: Cambridge University Press, 1988.

Mokyr, Joel, *The Enlightened Economy: An Economic History Britain*, 1700-1850, New Haven: Yale University Press, 2009.
---------The lever of riches: Technological creativity and economic progress, Oxford: Oxford University Press, 1990.
Page, William, ed. A History of the County of Middlesex: Volume 2, General; Ashford, East Bedfont With Hatton, Feltham, Hampton with Hampton Wick, Hanworth, Laleham, Littleton London: Victoria County History, 1911.
Polanyi, Michael, *The Tacit Dimension*, Gloucester, Mass.: Peter Smith, 1983.
Reilly, Robin, *Josiah Wedgwood, 1730-1795*, London: Macmillan, 1992.
Schmookler, Jacob, *Invention and Economic Growth*, Cambridge, Mass.: Harvard University Press, 1966.
Sherman, Brad and Lionel Bently, The Making of Modern Intellectual Property Law, The British Experience, 1760-1911, Cambridge: Cambridge University Press, 1999.
Warburton, W. H., The History of Trade Union Organisation in the North Staffordshire Potteries, London: George Allen & Unwin Ltd, 1931
Weatherill, Lorna, *The Growth of the Pottery Industry in England 1660-1815*, London: Garland Publishing Inc., 1986.

Articles / Book Chapters

Allen, Robert, 'Collective Invention.' *Journal of Economic Behaviour and Organization* 4, no. 1 (1983): 1-24.
--------- 'Why the Industrial Revolution was British: commerce, induced invention, and the scientific revolution.' *The Economic History Review* 64, no. 2 (2011): 357-84.
Bessen, James, and Alessandro Nuvolari, 'Knowledge Sharing Among Inventors: Some Historical Perspectives.' *LEM Working Paper,* no 11-51, (2011).
Bruland, Kristine, and David C Mowery, 'Innovation through Time.' In *The Oxford Handbook of Innovation,* eds. J. Fagerberg and D. Mowery, Oxford: Oxford University Press, 2006, 349-79.
Epstein, Stephan R., 'Property Rights to Technical Knowledge in Premodern Europe, 1300-1800.' *American Economic Review* 94, no. 2 (2004): 382-7.
Lamb, A., 'The Press and Labour Response to Pottery-making Machinery in the North Staffordshire Pottery Industry.' *Journal of Ceramic History* 9 (1977): 1-7.
MacLeod, Christine, 'Strategies for Innovation: The Diffusion of New Technology in Nineteenth-Century British Industry.' *The Economic History* Review 45, no. 2 (May, 1992): 285-307.
Marsden, Ben, 'Carriages, coffee-cups and dynamometers: representing French technical cultures in the London Mechanics' Magazine, 1823-1848.' *Documents pour l'histoire des techniques* 19, (2nd semester 2010): 243-54.
McKendrick, N., 'Josiah Wedgwood and the Commercialization of the Potteries.' In *The Birth of a Consumer Society: The Commercialization of Eighteenth-century England*, eds. N. McKendrick, John Brewer and J. H. Plumb, London: Europa, 1982, 100-145.

---------'Josiah Wedgwood: An Eighteenth-Century Entrepreneur in Salesmanship and Marketing Techniques', *The Economic History Review* 19, no. 3 (1960): 408-33.
---------'Josiah Wedgwood and Thomas Bentley: An Inventor-Entrepreneur Partnership in the Industrial Revolution', *Transactions of the Royal Historical Society* Fifth Series, 14 (1964): 1-33.
Molland, George, 'Bacon, Roger (c.1214–1292?)', *Oxford Dictionary of National Biography*, (Oxford University Press: Oxford, 2004) online at http://www.oxforddnb.com/view/article/1008, [accessed 12 Sept 2017].
Moser, Petra and Tom Nicholas, 'Prizes, Publicity, and Patents: Non-Monetary Awards as a Mechanism to Encourage Innovation.' *The Journal of Industrial Economics* 61, no. 3 (September 2013): 763-88.
Moser, Petra, 'How do patent laws influence innovation?' *The American Economic Review* 95, no. 4 (Sept 2005): 1214-36.
--------- 'Innovation without Patents – Evidence from World's Fairs.' *The Journal of Law and Economics* 55, no. 1 (Feb 2012): 43-74.
--------- 'Why don't inventors patent?' *NBER Working Paper Number* 13294, (August 2007).
Nuvolari, Alessandro, 'Collective Invention during the British Industrial Revolution: the case of the Cornish pumping engine.' *Cambridge Journal of Economics* 28, no. 3 (2004): 347-63.
Nuvolari, Alessandro and James Sumner, 'Inventors, Patents, and Inventive Activities in the English Brewing Industry, 1634-1850.' *Business History Review* 87 (2013): 95-120.
Nuvolari, Alessandro, and Valentina Tartari, 'Bennet Woodcroft and the value of English Patents, 1617-1841.' *Explorations in Economic History* 48 (2011): 97-115.
Peltonen, Markku, 'Bacon, Francis, Viscount St Alban (1561-1626)', *Oxford Dictionary of National Biography*, (Oxford University Press: Oxford, 2004), online at http://www.oxforddnb.com/view/article/990, [accessed 20 Sept 2017].
Popp, Andrew and Wilson, John F., 'Districts, networks and clusters in England: An introduction.' In *Industrial Clusters and Regional Business Networks in England, 1750-1970,* eds. Andrew Popp and John Wilson, Aldershot: Ashgate, 2003, 1-18.
Schaffer, Simon, 'Introduction.' In *The mindful hand: Inquiry and invention from the late Renaissance to early industrialisation,* eds. Lissa Roberts, Simon Schaffer and Peter Dear, Amsterdam: Edita KNAW, 2007, 85-94.
Smith, Keith, 'Measuring Innovation.' In *The Oxford Handbook of Innovation,* eds. J. Fagerberg and D. Mowery, Oxford: Oxford University Press, 2006, 148-78.
Storper Michael, and Anthony J. Venables, 'Buzz: face-to-face contact and the urban economy.' *Journal of Economic Geography* 4 (2004): 351-70.
Sullivan, Richard J., 'England's "Age of Invention": The Acceleration of Patents and Patentable Invention during the Industrial Revolution.' *Explorations in Economic History* 26, no. 4 (1989): 424-52.
Wallis, Patrick, 'Apprenticeship and Training in Premodern England.' *The Journal of Economic History* 68, no. 3 (2008): 832-61.