Secrets for sale? Innovation and the nature of knowledge in an early industrial district: the potteries, 1750-1851

Article

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Abstract

This article investigates innovation and knowledge circulation 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 private 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 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 article 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.

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

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 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 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'.[4] 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.[5] 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.[6]

Storper and Venables argue that intense concentration and proximity creates 'buzz' and face-to-face contact between individuals which, alongside other benefits, is crucial for 'creative activities' based on rapidly changing tacit knowledge that is difficult to codify.[7] 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.[8] Much of the innovation and technical progress in this important industry before and during the Industrial Revolution concerned the quality of the products.[9] 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 article 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 article begins with a short review of the existing literature and a discussion of the discovery of a single, hitherto unknown and conceivably unique, newspaper 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 article 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.[10]

The second part of the article 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'. [11]

The article 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 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.[12] 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.[13]

2. Review

There is a fascination with porcelain, ceramics and earthenware to which art and museum galleries are dedicated across the globe. Academic study of one of the most important pottery producing regions in the world has been relatively limited, however, when compared to cotton textile production in the north of England, or the advent of steam technology, for example. An early example of sustained and focused research into the North Staffordshire Potteries is found in the work of Simeon Shaw who published an account of the success and vitality of the region in 1829.[14] Whilst Shaw was keen to heap praise on the progress of the industry, he demonstrates remarkable insight and is one of the earliest commentators to acknowledge the collective sentiments of the North Staffordshire potters. The collective community that inhabited the district thrived 'by uniting talents and perseverance, [and] the recesses of the earth [had] been explored to enrich its owners'.[15] This pioneering assessment of the district remained largely ignored for much of the nineteenth century and it was over a century and a half later before the importance of the collective identity and action of the potters was acknowledged in academic literature and associated with the economic fortune of the region.[16] It was not until the middle of the twentieth century that the region began to be studied in any great detail, with much of the focus placed on the introduction of machinery in the later nineteenth century, the history of the Trade Union Organisation, or the entrepreneurial talents of Josiah Wedgwood.[17]

In recent years the fields of regional and business history have ignited a renewed academic interest in the Potteries as an industrial district.[18] This interest stems from a wider historiographical shift in social and economic history which has seen an increased recognition of the value of localised and regional study when thinking about the features and patterns of industrialisation processes.[19] The study of invention and innovative activities during the British Industrial Revolution has also 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.[20] 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.[21] There are general limitations concerning the utility of patents given that not all innovations were patented, and not all patents reflected true innovations.[22] 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.[23] Their works have built on and revised earlier studies by Dutton and MacLeod on innovation and patenting in England during the transition to modern economic growth.[24] 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.[25] 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.[26] 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.[27] This has clear implications for strategies and decision-making regarding secrecy vis-à-vis open knowledge sharing.

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.[28] 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.[29] More recently, Allen has More recently, Allen has expanded his argument to claim for the pervasiveness of collective invention in Britain during the eighteenth century.[30]

An important point to note is that Allen's classic 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.[31] However, in a brief comment on innovation in the pottery industry specifically, Allen has suggested that collective invention could take place, in spite of conscious attempts by contemporaries to suppress it.[32] This is an important qualifier and deserves discussion here as Allen also argues that inventors in the industry fell into several different categories that formed a complex web of interaction and innovation. In addition to those archetypal *Industrial Enlightenment* genius-type scientifically-based-experimenters (William Cookworthy 1705-80, John Dwight 1633-1703, Josiah Wedgwood 1730-95) there were artisans who relied on apprenticeship and experience to develop some of the most important innovations in the industry (e.g. creamware, double-firing and transfer printing). This, he argues, is evidence of an effusion of innovation from below, rather than above. Whilst this was certainly a *part* of the innovative environment in the Potteries, this feature does not, as Allen suggests, support any argument for collective invention in the region. If we follow Allen's argument through collective invention can only be applied to the pottery industry as an unintentional bi-product and consequence of

employee turnover between firms, and not *wilful*, or *open* sharing of knowledge and ideas.[33] In the author's opinion, this does not constitute collective invention. The evidence presented in this article will, amongst other things, demonstrate that in the pottery industry, attempts to suppress collective invention were successful.

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.[34] 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.[35] 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.

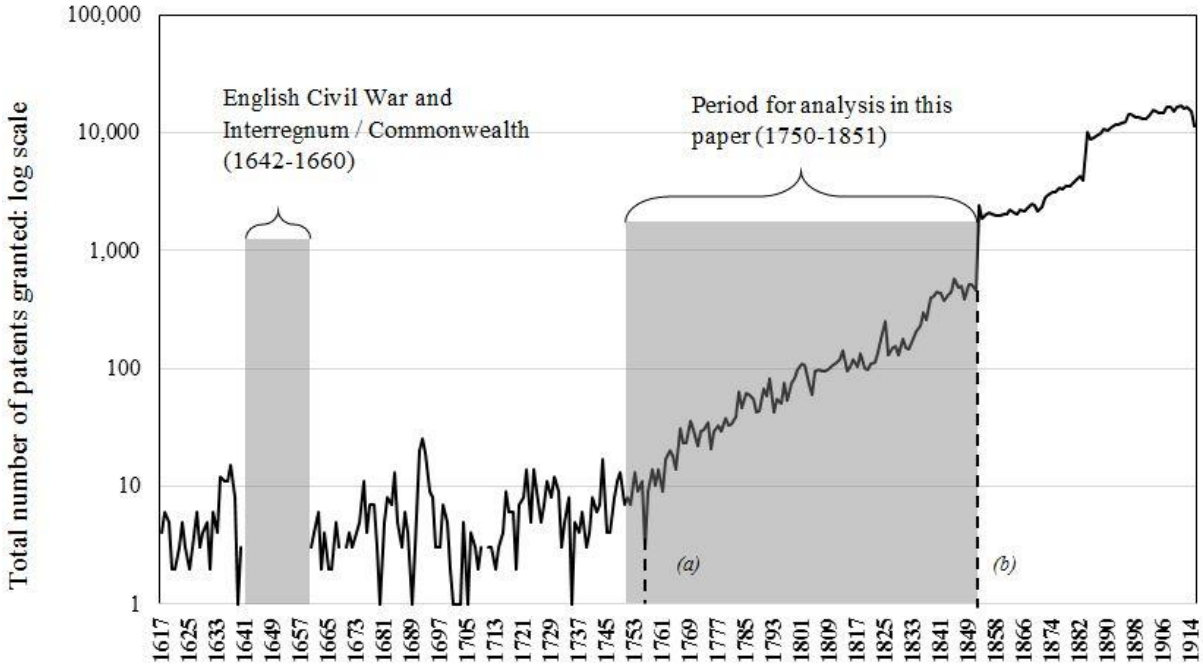
3. Patenting in the English Pottery Industry

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.[36]

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.[37] 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.[38] The *Abridgments* relating to pottery have not hitherto been used widely and to the author's knowledge, this is first such study to engage with this source in systematic detail.

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.

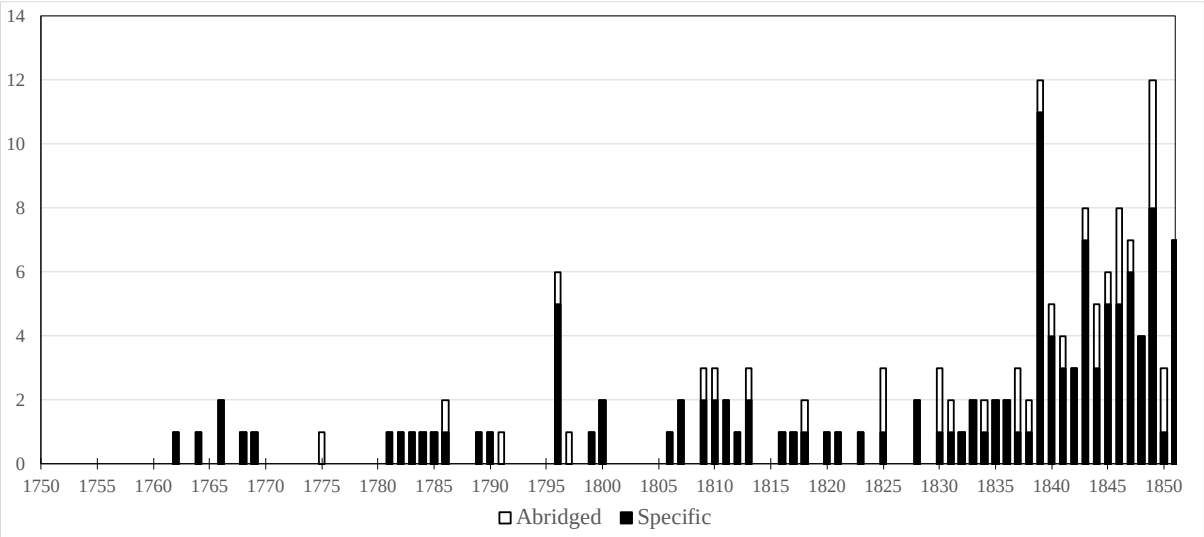
Sources:

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. Compiling Woodcroft's indexes and cross-checking the titles of every patent granted in England for the period, there were 175 'pottery related' patents granted between 1617 and 1851.[39] This number compiled using Woodcroft's works may be

somewhat misleading due to the chance that any reference by the patentee to a specific industry 'may be entirely speculative', not to mention human error by Woodcroft's employees at the Patent Office.[40] To mitigate this problem each of the 175 'Woodcroft' specifications has been examined by the author to remove those very broad patents with tenuous or irrelevant references to pottery. This process leaves 139 'specific' patents for the entire period 1617-1851.[41]

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 as determined by the author. Where hollow columns appear, these represent those additional patents identified in Woodcroft's 'Abridged' list as being pottery related (hereafter referred to as 'Woodcroft' patents).

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.[42] To provide a relative measure, Table 1 shows both the 'Woodcroft' 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 3.42 per cent of all patents.[43]

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

Years	***1617-1700***	***1701-1750***	***1751-1800***	***1801-1851***	**Total**
Total Patents	431	292	1,804	11,484	14,011
Pottery Patents (Woodcroft)	7	10	27	131	175
Share of total (%)	1.62%	3.42%	1.50%	1.14%	1.25%
Pottery Patents (specific)	7	10	22	100	139
Share of total (%)	1.62%	3.42%	1.22%	0.87%	0.99%

Notes: see main text for distinction between 'Woodcroft' 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'.[44] 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

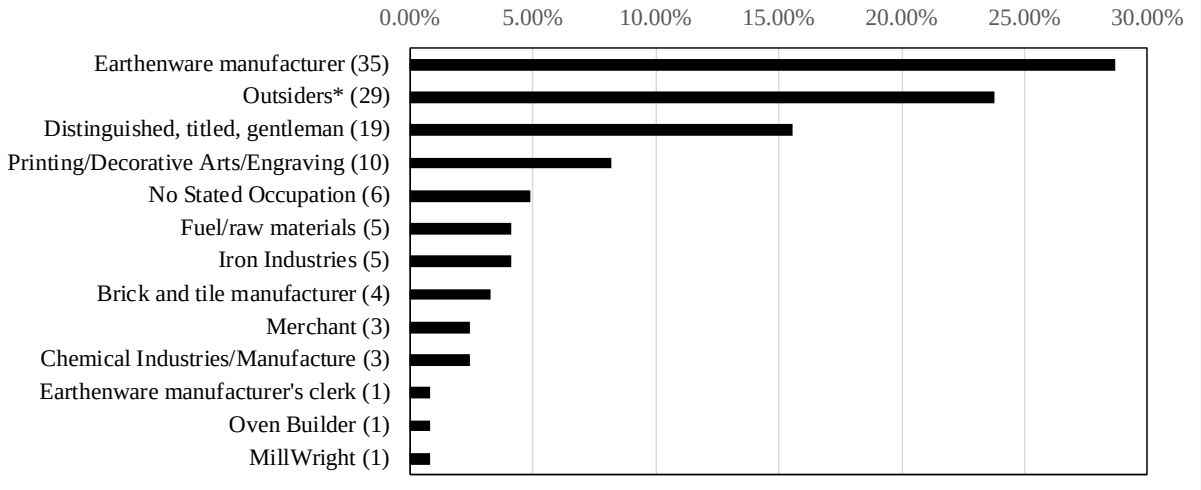
Years	***1751-1800***	***1801-1850***	**Total**
Total patents	1,804	10,974	12,778
'Genuine' Brewing Patents	21	62	83
Share of total (%)	1.16%	0.56%	0.65%
Pottery Patents (specific)	22	100	122
Share of total (%)	1.22%	0.91%	0.95%

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.[45] The majority of 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.[46] 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.[47] The third largest group of patentees were the upper societal elite who held just over 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'.[48]

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, Doctor in Philosophy, Doctor in Physics, Engineer, Engineer and Designer, Gas Engineer, Gold and Silver Smith, Manufacturer, Mechanical Draughtsman, Paper Maker, Stove Grate Maker, Victualler and Wharfinger.

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 and contrasts with 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 forty per cent during the 'boom' period of pottery patenting of 1835-1851. Of the 47 pottery patents originating in Staffordshire, just one was held by a patentee that was not resident in the Potteries district: George Thorneycroft, an iron founder from Wolverhampton designed a machine for 'rolling, squeezing, or compressing puddle balls of iron' which could also be used for grinding raw materials for the production of pottery.[49] The geography of patenting activity in the pottery industry changed as the 19th century progressed with more patents being granted outside of the region than inside.

Figure 4: Geographical distribution of pottery patents held by potters and non-potters, 1617-1851

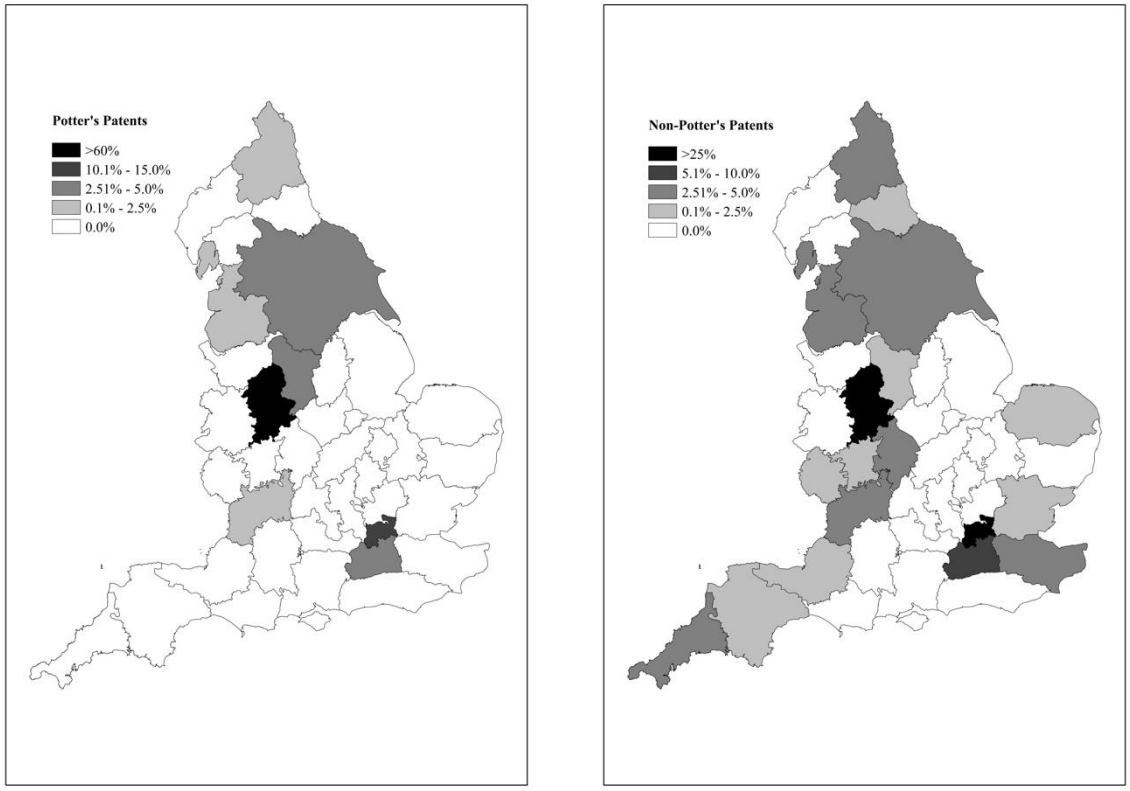


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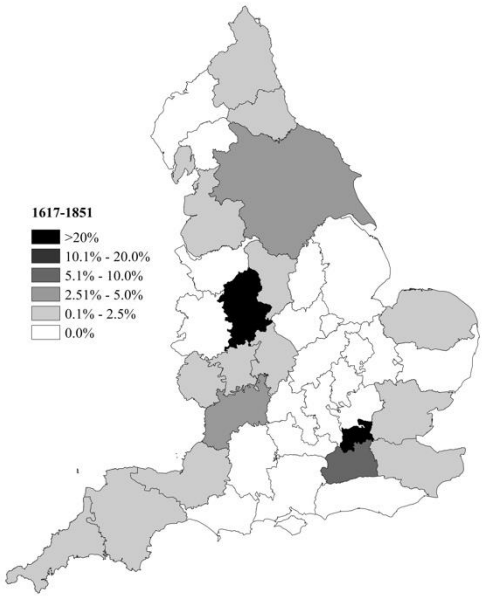
Figure 5 shows the distribution of pottery patents in each county as a percentage share of total pottery patents for England. It also shows pottery patents per capita in 1851. The predominance of London, Middlesex and Surrey alongside Staffordshire is not surprising when we consider national trends in 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.[50] In his study of the Cornish mining industry, Nuvolari 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 urbanisation and growth of London and the geographical location of the patent office, as noted by Inkster.[51] 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 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 with a very light spread through an industrial belt running from Yorkshire and Northumbria in the northeast, through the midlands into Cornwall and the southwest. Secondly, Cornwall had an extremely low number of patents for steam engines relative to the 'major contribution' of the region to steam power.[52] 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.[53] 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.

A recently updated index by Nuvolari and Tranchero allows us to use the patent data presented here to compare the quality of patents based on different variables.[54] Using this quality measure alongside the location data shows that, on average, patents that originated within Staffordshire were of a higher quality

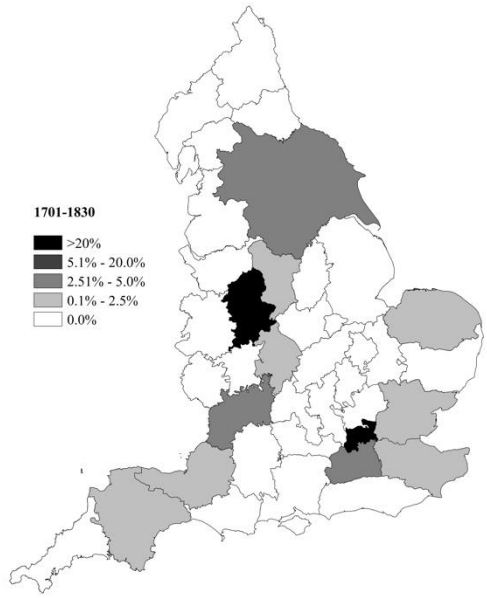
than those that came from outside the county. Occupational data shows that patents that were held by potters were, on average, higher quality than those held by non-potters.

Figure 5: Geographical distribution of pottery patents in England

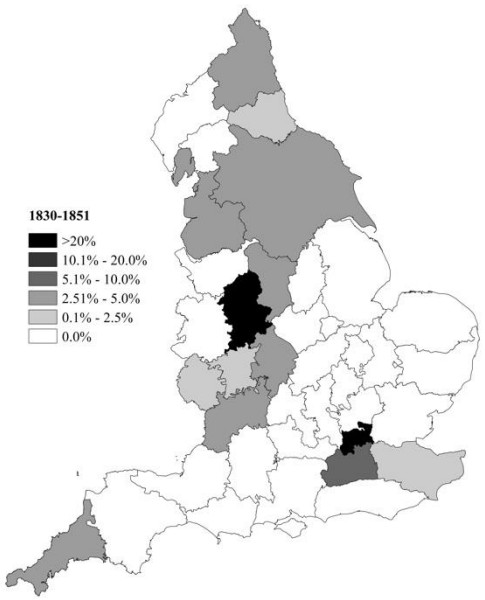
Pottery patents by county, 1617-1851 (% of total)



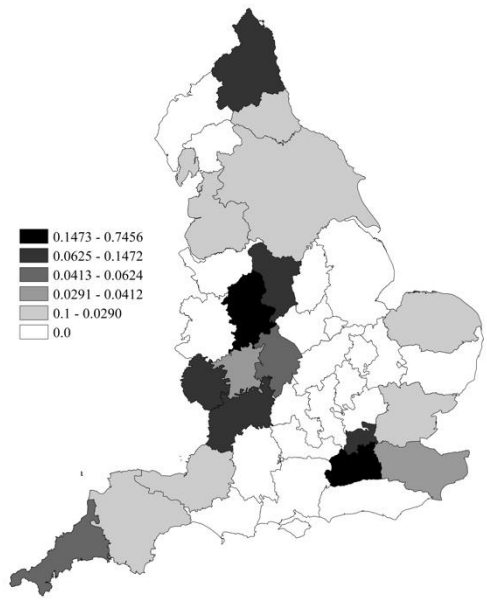
Pottery patents by county, 1701-1830 (% of total)



Pottery patents by county, 1830-1851 (% of total)



Pottery patents per 10,000 inhabitants, 1617-1851

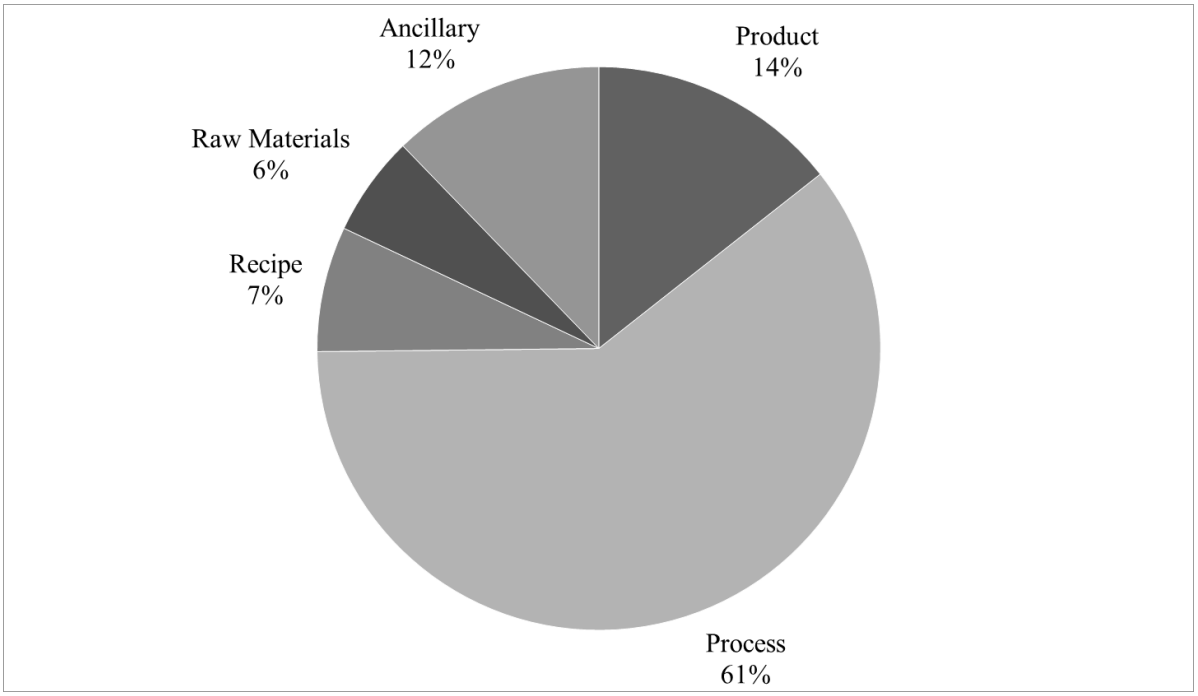


The key points to take from this analysis so far are firstly, patenting was *not* widespread in the pottery industry and was extremely scarce until the 1840s. Patenting an innovation was not a strategy that was widely employed in the industry. Moreover, according to Nuvolari and Tranchero's quality index, those patents that were held by Staffordshire potters were generally of a higher quality than those from outside the industry and district. Secondly, although earthenware manufacturers themselves were the largest single group of patentees, 70 per cent of patents came from non-potters, the majority 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.[55] 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.

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.[56] Just 12 per cent of patents were for product innovations such as Cookworthy's English porcelain, or the garden pots of Cutten and Brown.[57] Of the patents issued between 1750 and 1851, over 40 per cent of these related to process innovations which, to anyone with knowledge of the industry, 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.

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. As the evidence shown below will demonstrate, patent specifications in the English pottery industry can 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 some cases (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.

A second type of patent, vague, abstract and sometimes incomprehensible, offered little valuable information to a reader and often, though not always, only signified that some sort of innovation had occurred.[58] The knowledge in this second types of patent 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 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'.[59] 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. The patent specifications below are representative of the entire sample and are particularly revealing.

The first patent examined, 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.

<u>Patent 649: Thomas Frye – a new method of making a certain ware</u>

17th Nov. 1749 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.

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.[60]

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 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.[61] 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.[62] 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.[63] 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.[64] 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.'[65]

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.

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

16th Nov. 1769 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.

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.[66]

A full and complete specification was printed in the *Repertory of patent inventions* published in 1797.[67] 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 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.[68] There was considerable scepticism, albeit only published four years later in Newton's *London Journal*, concerning the degree of novelty in this innovation, and indeed whether the specification provided any new information or knowledge.[69] The *London Journal* provides an account of the specification which is useful here:

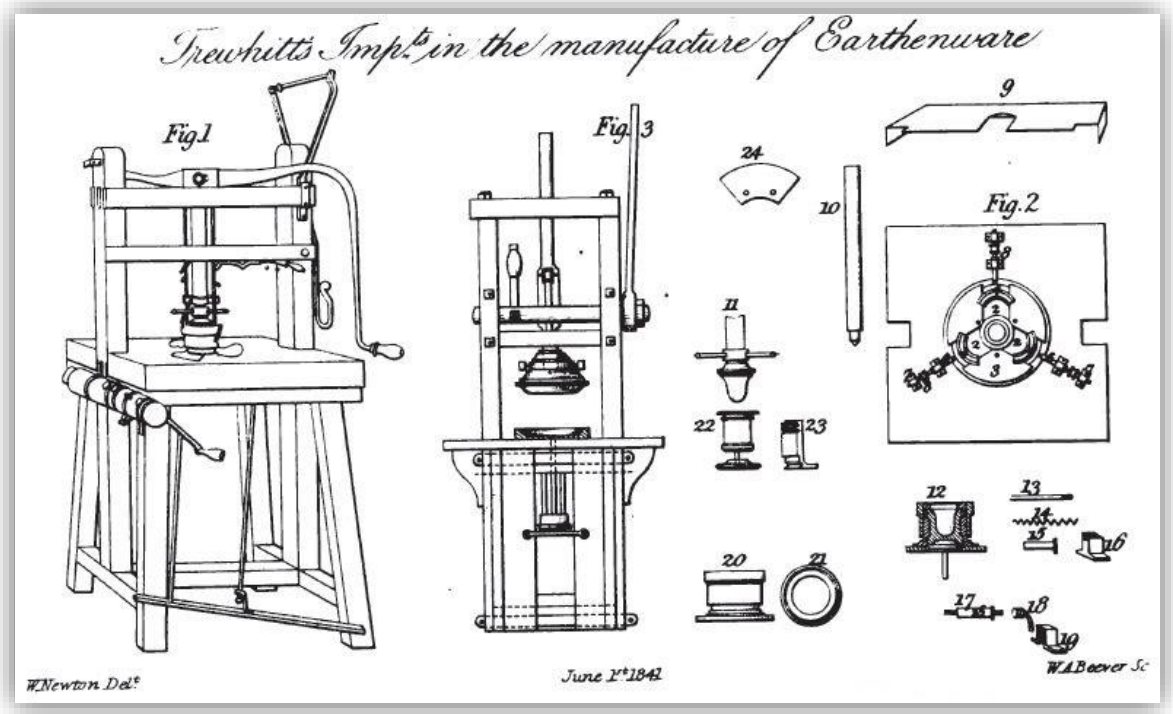
> *This invention appears to us to possess but a very slight degree of novelty, the whole of the invention consisting in adding a little gum to the ordinary composition in use among potters, and known by the name of gold lustre […] but for what purpose this ingredient is added, the specification does not inform us.*[70]

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 patent was not published or referenced in any repository other than the *London Journal*, and the late nature of this suggests that the patent did not garner much attention at the time it was awarded.[71]

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 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.[72] 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'.[73]

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.[74] 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.[75]

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



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Potters during this period had no recourse to other forms of intellectual property protection for their innovations. 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.[77] 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.[78] 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.[79] 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.

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.[80]

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.[81] 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.[82] 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.[83]

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.'[84] The criteria of novelty, invention and innovation were exacting and, overall, applied relatively evenly.[85] Given this, the awarding of a prize may be taken as an indication, 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. The items displayed at the Exhibition or those awarded prizes do not, however, constitute a measure of the quantity of innovation in the industry.

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. Within the earthenware exhibit awards, quality was almost never explicitly 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.[86] In a study of exhibitions and prizes in the US context, Khan questions the degree to which award criteria were adhered to by judging panels. In the case of the Massachusetts Charitable Mechanics' Association exhibitions between 1837 and 1874, novelty took a backseat to 'appearance and workmanship' as a judging criteria.[87] Khan also notes that 'British great inventors primarily depended on their background rather than on their productivity' to win a prize at a fair; especially whether they attended elite schools such as Oxford or Cambridge.[88] There is, therefore, no consensus concerning novelty and the awarding or impact of prizes at exhibitions such as those at the Crystal Palace or Massachusetts. This is not to be unexpected, however, given the considerable differences in the intellectual property systems on either side of the Atlantic. For instance, in the US public display of inventions and innovations could compromise an inventor's ability to claim novelty, and thus be granted a patent. In the UK, tensions over whether to display an innovation certainly existed (as it would reveal certain features), although the decision would not impact on the obtainment of a patent as these could be awarded later.

The award citations for 1851 suggest that novelty and innovation in the earthenware sector 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.

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 II was awarded a 'Large Gold Medal' by *The Society of Arts* for his production of a new lead-free glaze.[89] 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.'*[90]

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.'*[91]

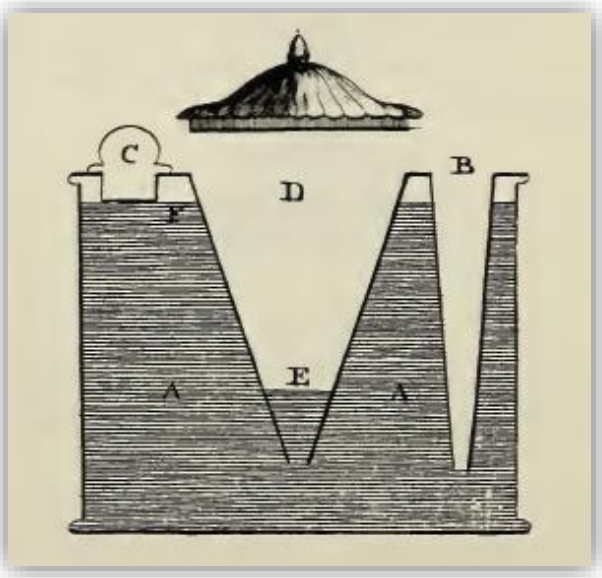
The knowledge and secrets which could have been appropriated by Meigh himself were published, although in a very rudimentary format, and thus made publicly available.[92] A patent may have allowed Meigh to appropriate some of the gains from this discovery although in the event he was bound by the decree 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.'[93]

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.[94] 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.[95] 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.'[96] 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.[97] 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.'[98] 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.[99] 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 'moderately skilled painters' to achieve high levels of quality and likeness.[100] 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.[101]

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



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, 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'.[102] 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.[103] 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. [104] 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.[105] Following Polanyi's dictum once more, the type of skills required for pottery or any other intensive craft based production rely on the craftsman's 'awareness of a combination of muscular acts for attending to the performance of a skill.'[106] 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.[107] 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.[108]

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.[109] 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'.[110] The specification is relatively short and is vague when describing the characteristics of the new substance:

> *'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.'.*[111]

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.'*[112]

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.'[113]

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 workman will use his judgment in the quantity he employs, according to the effect he desires to obtain.'[114] 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.[115] 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'.[116] 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'.

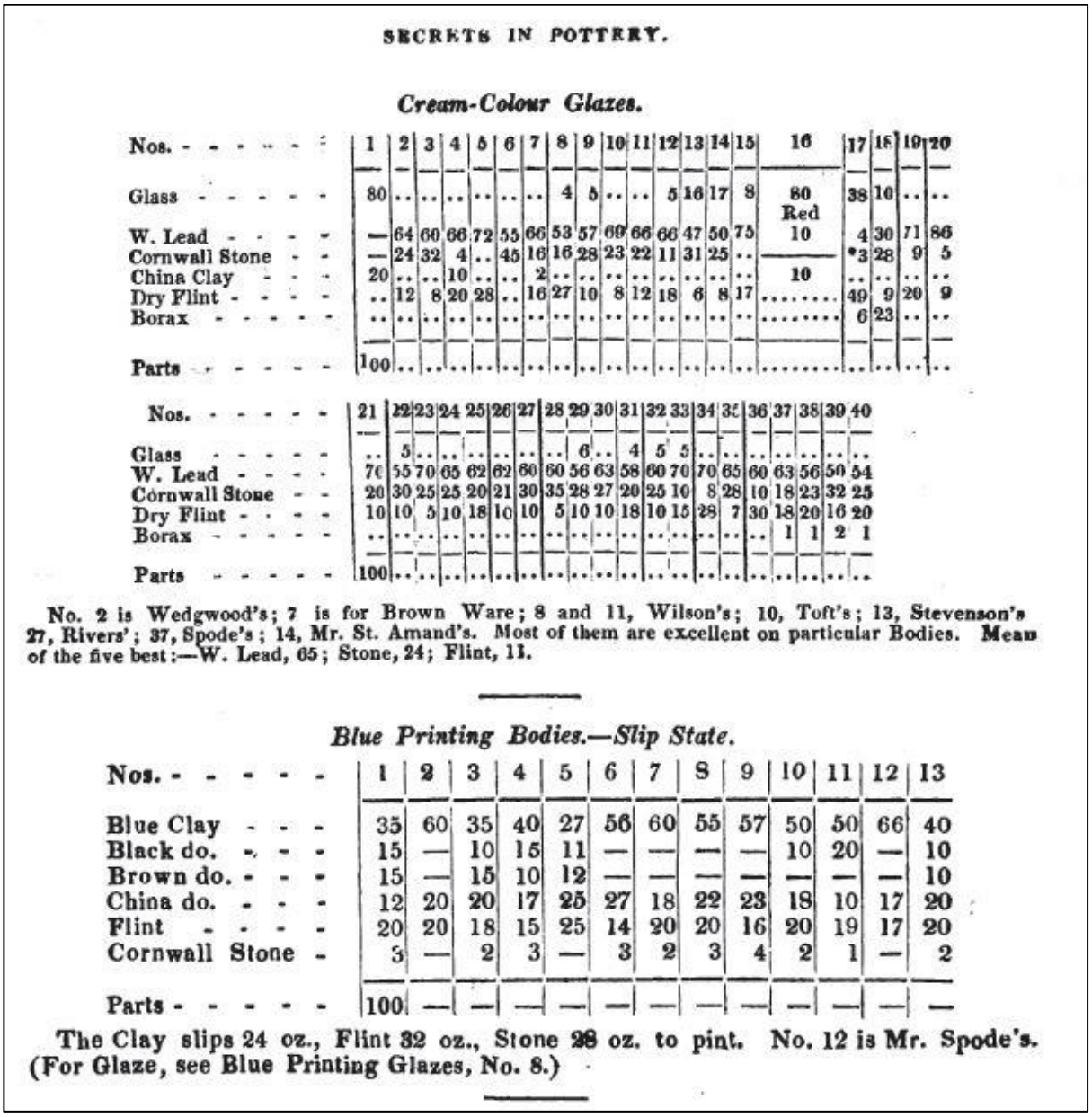
Friar Bacon's identity remains a mystery, although there are several possible scenarios based on conjecture. The choice of moniker is an interesting one. It could be a reference to Roger Bacon (c.1214-c.1292), the English natural philosopher and Franciscan Friar with an interest and skill in optics and mathematics.[117] 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.

The industry took secrets seriously, and recognised that many parts of the production process could leak or spill out of the boundary of a firm with the movement of labour between partnerships.[118] In the highly likely event that workers were exposed to secrets relating to production in any manufactory, in 1837 the local Chamber of Commerce saw fit to include a clause in their employment contracts to prevent, as far as possible, these secrets being revealed.

> *'the said Workman agrees to do and perform his work in a good skilful and workmanlike manner, and to attend to the business of his said employer, during the regular and usual working hours; to execute lawful commands, preserve secrets, advance interests to the utmost of his power, and in all respects to behave as an honest and faithful servant.'*[119]

Similar approaches to the protection of corporate knowledge and trade secrets can be found in the non-compete clauses common in high-tech industries today.[120]

Figure 9: 'Secrets in Pottery' compiled by Friar Bacon of Hulton Abbey



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.

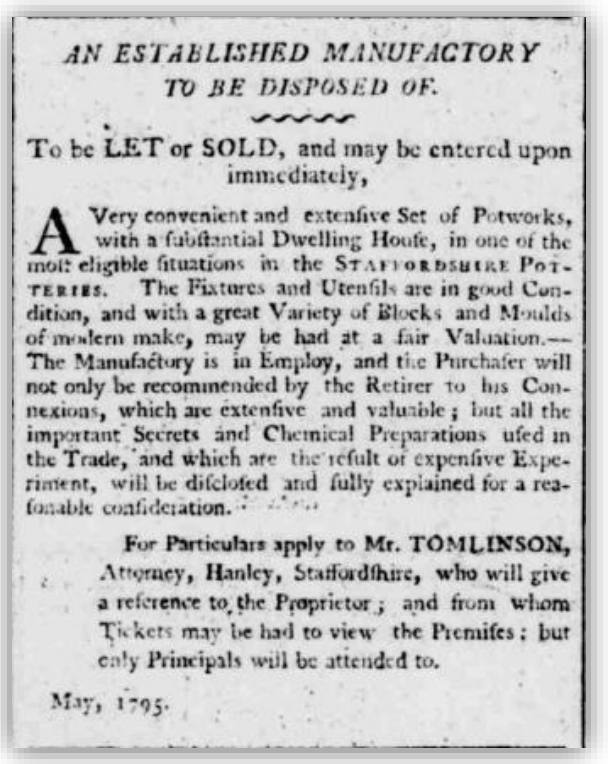
A response came in June 1833, several months after the publication of these original recipes, when a 'constant reader' from Newcastle-under-Lyme in the Potteries raised their concern over the publication of secrets. In a short statement the reader noted that the Friar's actions had 'put all in commotion'.[121] Objections to the disclosure were raised though the reader went on to express his pleasure in receiving the 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.'[122] 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.'[123] 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.[124] 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.

In terms of the impact of this episode, although there is clear recognition that divulging of secrets was a potential threat to a business and the wider industry, and the requirement that workers agree to a contract preventing this activity, it is not known whether mention of secrets was added specifically as a result of Friar Bacon's divulgences. Moreover, 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 showed in Figure 10. It is difficult to ascertain whether there were any new entrants to the market as a result of the glut of recipes that were published in the *Magazine*. The number and composition of firms operating in the region between 1781 and 1846 has been reconstructed using trade directories. Whilst there was a slight increase in the number of producers between 1830 and 1834 (two years of directory publication), it is not clear whether this is due to the different authors of the directories using different criteria for inclusion, or due to some other factor unrelated to this incident.

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

Figure 10: Advertisement placed in Staffordshire Advertiser



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.

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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 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.[126]

This informal market differs fundamentally in nature from the more formal markets for technology and knowledge noted by Lamoreaux and Sokoloff in the US during the late nineteenth and early twentieth centuries.[127] In the American context, the patent system worked as an 'institutional framework' for a market for technology, serving as an information and marketing channels enabling inventors and would-

be inventors to keep up with developments in their field, or avoid potential infringements.[128] In the North Staffordshire context, knowledge and technical information flowed throughout the district despite the scarcity of inventors taking up formal intellectual property protection for their innovations. Of course, the two contexts differ substantially with mechanisation far more widespread in the former than in the latter.[129] Rather, in terms of a 'market for technology', the North Staffordshire Potteries could perhaps more closely resemble the brewing industry discussed by Nuvolari and Sumner: a wide range of 'appropriability strategies' were employed as a means of sharing or protecting useful and technical information.[130]

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.[131] Trading 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.[132] 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.[133]

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.[134] 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.'[135] 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.[136]

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'.[137]

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'.[138] 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.[139] Clearly there was a high degree of uncertainty and anxiety over keeping trade secrets secret.

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.[140] This article 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.[141]

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. 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.[142] 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 article, we can draw a relatively robust conclusion. The pottery industry exhibited some, but not all, of the core features of collective invention. Innovation 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 relation to the need for *incremental* innovation to qualify as collective invention, it is not entirely clear from the evidence discussed here that innovation in the Potteries met this criteria in the sense captured by Allen and Nuvolari. The nature and context of innovation in the pottery industry and the two classic examples of collective invention (iron production in Cleveland and steam technology in Cornwall) are important in this regard. For instance, consider the core products of these three regions. The focus of Allen's collective invention' narrative was the Cleveland district which produced pig-iron, an input material for a range of other products and industries, and the key innovations related to the size and heat of blast-furnaces.[143] The Cornish mining districts, the locale for Nuvolari's 'collective invention settings', produced copper and tin, neither of which were final products, with the core innovations being in steam technologies.[144] The North Staffordshire Potteries produced finished earthenware products that would be sold directly to final consumers, and key innovations tended to be focused on glazes, bodies, colours and shapes (as well as design and style). These differences have important implications for the technological trajectories of the three regions, and thus important implications for collective invention. The technological trajectories of Cleveland and Cornwall were characterised by cumulative or incremental innovations. For example, the optimally efficient height of a furnace and its temperature were arrived upon by small incremental design changes and additions of height several feet at a time. Likewise, the pumping engines that proved so crucial to the Cornish mining

industry were the result of incremental improvements and increases in features such as steam pressure, boiler surface and cylinder diameter.[145] Advances in glazes, body composition and styles of earthenware products were perhaps somewhat more discrete. Of course, there were innovations in scientific knowledge and understanding of chemical compositions that were crucial to numerous subsequent innovations, such as the development of lead-free glazes.[146] Nevertheless, innovation in the pottery industry was far more varied and diverse in its trajectory and was not a series of incremental improvements along one key plane, such as the steam engine.

Finally, in answer to the question raised earlier in the article: 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.

Bibliography

Primary Sources

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

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

Mechanics' Magazine (1823-1872)

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

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 / Theses

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.

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

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.

Hudson, Pat (ed.), *Regions and Industries: Perspectives on the Industrial Revolution*, Cambridge: Cambridge University Press, 1989.

Inkster, Ian, *Science and Technology in History, An Approach to Industrial Development*, Basingstoke: Macmillan, 1991.

Lane, Joseph, *Networks, Innovation and Knowledge: The North Staffordshire Potteries, 1750-1851*, unpublished PhD thesis, London School of Economics, 2018, online at: http://etheses.lse.ac.uk/3702/1/Lane__networks-innovation-and-knowledge.pdf

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.

Shaw, Simeon, *History of the Staffordshire potteries, and the rise and progress of the manufacture of pottery and porcelain, with notices of eminent potters,* London: Scott, 1900, reissue of original 1829 edition.

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.

--------- 'Technology.' In *The Cambridge Economic History of Modern Britain, Volume 1: 1700-1870,* eds. R. Floud, J. Humphries and P. Johnson, Cambridge: Cambridge University Press, 2014, 292-320.

--------- 'Why the Industrial Revolution was British: commerce, induced invention, and the scientific revolution.' *The Economic History Review* 64, no. 2 (2011): 357-84.

Berg, Maxine and Pat Hudson, 'Rehabilitating the Industrial Revolution', *The Economic History Review*, 45, no. 1 (1992), 24-50.

Bessen, James, and Alessandro Nuvolari, 'Knowledge Sharing Among Inventors: Some Historical Perspectives.' In *Revolutionizing Innovation: Users, Communities and Open Innovation,* eds. D. Harhoff and K. Lakhani, Cambridge, Mass.: MIT Press, 2016, 135-156.

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.

Celoria, F., 'Ceramic Machinery of the Nineteenth Century in the Potteries and in Other Parts of Britain', *Staffordshire Archaeology*, 2 (1973), 10-48.

Epstein, Stephan R., 'Property Rights to Technical Knowledge in Premodern Europe, 1300-1800.' *American Economic Review*, 94, no. 2 (2004), 382-7.

Khan, B. Zorina, 'Going for Gold: Industrial Fairs and Innovation in the Nineteenth-Century United States.' *Revue économique*, 64, no. 1 (2013), 89-113.

Kyriazidou, E., and Martin Pesendorfer, 'Viennese Chairs: A Case Study for Modern Industrialization.' *The Journal of Economic History*, 59, no. 1 (1999): 143-66.

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.

Lamoreaux, Naomi, and Kenneth Sokoloff, 'Inventors, Firms, and the Market for Technology in the Late Nineteenth and Early Twentieth Centuries.' In *Learning by Doing in Markets, Firms and Countries*, eds. N. Lamoreaux, D. Raff and P. Temin, Chicago: University of Chicago Press, 1999, 19-60.

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.

Marx, Matt, Deborah Strumsky and Lee Fleming, 'Mobility, Skills, and the Michigan Non-Compete Experiment', *Management Science*, 55, no. 6 (2009), 875-889.

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 and Cost Accounting in the Industrial Revolution', *The Economic History Review*, 23, no. 1 (1970), 45-67.

---------'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.

Nuvolari, Alessandro, and Matteo Tranchero "Patterns of Innovation during the Industrial revolution: a reappraisal using composite indicators of patent quality", forthcoming working paper, details from personal correspondence with author.

Popp, Andrew, '"The true potter": identity and entrepreneurship in the North Staffordshire Potteries in the later nineteenth century', *Journal of Historical Geography*, 29, no. 3 (2003), 317-335.

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.

[1] Weatherill, *The Growth*, 43.

[2] Table 82, *Tables of the Revenue*, 98

[3] Blaszczyk, *Imagining Consumers*, 4-9; Berg, *Luxury and pleasure*; McKendrick, 'Josiah Wedgwood' in *The Birth*, eds. McKendrick *et al*, 100-145

[4] With many producers producing similar-looking wares, and creamware and jasperware becoming popular in the late eighteenth century, the distinctive produce of the region such as creamware and jasperware quickly became known as Staffordshireware. A further notable example regionally designated collective nouns to describe wares can be found in the Viennese furniture making industry during the second half of the nineteenth century: chairs, regardless of which firm produced them, became known as 'Viennese Chairs': see Kyriazidou and Pesendorfer, *Viennese Chairs*.

[5] Popp and Wilson, 'Districts, networks and clusters', in *Industrial Clusters*, eds. Popp and Wilson, 14-15.

[6] For estimated aggregate figures see: Weatherill, *The Growth*, 440-453

[7] Storper and Venables, 'Buzz', 351-370.

[8] Burchill and Ross, *A History*, 154; Lamb, 'The Press', 6.

[9] Allen, 'Technology', 307

[10] For an overview of the tacit/explicit interpretation across various disciplines see Table 1 in Gourlay, 'Conceptualizing Knowledge', 1426.

[11] Moser, 'Why don't inventors patent?', 1.

[12] *Ibid.*, 3, 25-26

[13] Allen, 'Collective Invention', 1-24; Nuvolari, 'Collective Invention', 347-363.

[14] Shaw was employed in the district at Hanley Grammar School during the early nineteenth century and was a close friend of the potter Josiah Spode II, to whom the book was dedicated: Shaw, *History of the Staffordshire potteries*

[15] *Ibid.* 8-10

[16] Popp, 'The True Potter'.

[17] See: Burchill and Ross, *A History*; Warburton, *The History of Trade Union Organisation;* McKendrick, 'Josiah Wedgwood: An Eighteenth Century Entrepreneur', 'Josiah Wedgwood and Cost Accounting'; Celoria, 'Ceramic Machinery of the Nineteenth Century'; Lamb, 'The Press'.

[18] Popp and Wilson, 'Districts, networks and clusters', 14-15.

[19] Hudson (ed.), *Regions and Industries*; Berg and Hudson, 'Rehabilitating the Industrial Revolution'.

[20] Allen, 'Why the Industrial Revolution was British', 357-384; Mokyr, *The Enlightened Economy*.

[21] Moser, 'Patents and Innovation', 241.

[22] Schmookler, *Invention and Economic Growth*, 24; MacLeod, 'Strategies for Innovation', 288-9; Mokyr, *The Lever of Riches*, 251.

[23] Moser, 'Innovation without Patents', 43-74; Nuvolari and Sumner, 'Inventors', 95-120; Nuvolari and Tartari, 'Bennet Woodcroft', 97-115.

[24] Dutton, *The patent system*; MacLeod, *Inventing*.

[25] Allen, 'Collective Invention'.

[26] *Ibid.*

[27] See Table 1: *Ibid.*, 6-7.

[28] Bessen and Nuvolari, 'Knowledge Sharing', 135-156.

[29] *Ibid.*, 136; Mokyr, 'The institutional origins', 81.

[30] Allen 'Technology', 309.

[31] Allen, 'Collective Invention', 2; Nuvolari, 'Collective Invention', 361.

[32] Allen, 'Technology', 309.

[33] Allen introduces this notion in a short chapter on technology during the Industrial Revolution, in which he uses the ceramics industry as an exemplar of import imitation driving demand and innovation: 'Technology', 307-10.

[34] Bessen and Nuvolari, 'Knowledge Sharing'.

[35] Nuvolari, 'Collective Invention', 360.

[36] Bottomley, *The British patent system*, 64-5, 161-168.

[37] Sullivan, 'England's "Age of Invention"', 443.

[38] See 'Patent Sources' in Bibliography for these publications.

[39] Woodcroft, *Patents for Invention.* Woodcroft's *Titles of Patents* was meticulously checked to ensure no pottery-related patents were overlooked.

[40] Nuvolari and Sumner, 'Inventors', 99.

[41] Unless specifically related to pottery production, patents for brick and stone manufacture have been excluded from this analysis. As such, the figures presented here are different to those presented by Nuvolari and Tartari, *Bennet Woodcroft*.

[42] 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.

[43] The most notable coming from factories at Bow and Chelsea in the 1740s: Holgate, *New Hall*, 1-3.

[44] Nuvolari and Sumner, 'Inventors', 103-4.

[45] MacLeod, *Inventing*, 116.

[46] The majority of them are identifiable through the database of pottery firms compiled from trade directories in an earlier paper.

[47] See notes for Figure 3.

[48] Nuvolari and Sumner, 'Inventors', 104.

[49] Woodcroft, *Patents for Invention*, 46.

[50] MacLeod, *Inventing*, 119; Inkster, *Science and Technology*, 85.

[51] Nuvolari, 'Collective Invention', 357-8; Inkster, *Science and Technology*, 85.

[52] Nuvolari, 'Collective Invention', 358.

[53] Weatherill estimates that around four fifths of the English pottery industry (by employment) was located in the Potteries by 1815: see, Weatherill, *The Growth*, 453.

[54] I am grateful to Alessandro Nuvolari and Matteo Tranchero for sharing their unpublished data. This has been used (but not reproduced here) to determine any differences in quality between patents. See bibliography for forthcoming working paper.

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

[56] Patents 2140, 8338, 8339, 8340, 9901, 11912.

[57] Patents 898, 8254, 9518.

[58] Obscure and vague patent specifications were common in medical patents, and often used as a marketing or publicity device: MacLeod, *Inventing*, 85-6.

[59] Polanyi, *The Tacit Dimension*, 4, 10.

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

[61] Bottomley, *The British Patent System*, 181.

[62] I am grateful for the comments of an anonymous reviewer for raising this question of motives in this way.

[63] *A History of the County of Middlesex*, 146.

[64] Woodcroft, *Titles of Patents*, 114; *Patents for Inventions*, 6.

[65] Burton, *A History and Description*, 7-11.

[66] Woodcroft, *Titles of Patents,* 169; *Patents for Inventions*, 9.

[67] *The Repertory of Arts,* Vol. 7, 309-14.

[68] Woodcroft, *Patents for Inventions,* 29.

[69] *The London Journal of Arts*, Vol. 13, 22-3.

[70] *Ibid.*, 22.

[71] The majority of pottery patents were published or referenced in at least one publication, with 45 per cent featuring in two or more. 22 per cent of pottery patents were not published or referenced in any way. It is not known whether this patent successfully prevented the use of the materials laid out by Embrey.

[72] Lamb, 'The Press', 1; Warburton, *The History of Trade Union Organisation,* 191-2; Burchill and Ross, *A History,* 154.

[73] *The Repertory of Patent Inventions,* Vol. 17, 280-281.

[74] Patent no. 8295, Dec. 4 1839: *Titles of Patents,* 1095.

[75] *The London Journal of Arts*, Vol. 18, 297-300.

[76] *Ibid,* plate XII

[77] Macleod, *Inventing,* 67.

[78] *Ibid.*

[79] Sherman and Bently, *The Making,* 161-62.

[80] Moser, 'Innovation without patents', 43-47.

[81] Moser, 'How do patent laws', 1219.

[82] *Great Exhibition,* Vol. 2, 709-728

[83] *First Report of the Commissioners*; *Reports by the Juries.*

[84] *First Report of the Commissioners*, 202.

[85] In an industry in which aesthetics played a large part in the saleability of the end-product, 'novelty' refers here not only 'novel application of known discoveries', as stated in the award criteria, but also new designs, colours, shapes and styles. Novelty in design, for example, could be achieved without an innovation per se.

[86] *Reports by the Juries*, 1184; Moser and Nicholas, 'Prizes', 765.

[87] Khan 'Going for Gold', 91-93.

[88] *Ibid.*, 106.

[89] *Mechanics' Magazine*, Sat 8th May, 1824, 142.

[90] *Mechanics' Magazine,* Sat 31st Jan, 1824, 366.

[91] *Mechanics' Magazine,* Sat 8th May, 1824, 142.

[92] 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.

[93] *Transactions of the Society*, Vol. 40, vii-ix.

[94] see: McKendrick, 'Josiah Wedgwood: An Eighteenth Century Entrepreneur', 408-33; 'Josiah Wedgwood and Thomas Bentley', 1-33; Blaszczyk, *Imagining Consumers*.

[95] *The Wedgwood Catalogue.*

[96] *The Wedgwood Catalogue*, 31, 64, 66.

[97] 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.

[98] *The Wedgwood Catalogue*, 64.

[99] Reilly, *Josiah Wedgwood*, 79.

[100] *Ibid.*

[101] *The Wedgwood Catalogue*, 67.

[102] *Mechanics' Magazine*, Sat 5th November, 1825, 46.

[103] *Mechanics' Magazine,* Sat 6th April, 1839, 14-15.

[104] Epstein, 'Property Rights', 382.

[105] *Mechanics' Magazine,* Sat 6th April, 1839, 15.

[106] Polanyi, *The Tacit Dimension*, 4, 10.

[107] Collins, *Artificial Experts*, 85.

[108] Collins, *Tacit and Explicit*, 1-4.

[109] *Mechanics' Magazine,* 31 March, 1833, 434.

[110] *The Repertory of Arts and Manufactures* (Vol. 12, 1800), 299.

[111] *Ibid.*, 300

[112] *Ibid.*

[113] *Ibid.*, 301-2.

[114] *The Repertory of Patent Inventions* (Vol. 19, 1852), 353

[115] 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), 260; *The Inventors' Advocate, and Journal of Industry* (Vol. 1, 1841), 309; *The Patent Journal, and Inventors' Magazine* (Vol. 1, 1846), 136.

[116] *Mechanics' Magazine,* 31 March, 1833, 433.

[117] Molland, 'Bacon, Roger'.

[118] For a reconstruction of the partnership patterns of Staffordshire potters 1781-1851 see Lane, *Networks, Innovation and Knowledge*, 57-110.

[119] *Staffordshire Advertiser,* Sat 7th Jan, 1837.

[120] Marx, Strumsky and Fleming, 'Mobility'.

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

[122] *Ibid.*

[123] *Ibid.*

[124] *Mechanics' Magazine,* 20 July, 1833, 263.

[125] *Staffordshire Advertiser,* Sat 16th May, 1795

[126] The author has conducted searches of 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 dates see bibliography.

[127] Lamoreaux and Sokoloff, 'Inventors, Firms'.

[128] *Ibid.*, 23-4.

[129] Based on the results presented in this article, the impact of mechanisation affected the ability and propensity to patent significantly.

[130] Most notably: secrecy, partial publication and revelation, open-innovation and patenting.

[131] Bottomley, *The British Patent System*, 204-5.

[132] *Ibid.*

[133] *Ibid.*

[134] Dutton, *The Patent System*, 26-7.

[135] *Papers Relative to Mr Champion's Application*.

[136] MacLeod, *Inventing*, 63.

[137] Spiker, *Travels*, 81.

[138] Letter from Josiah Wedgwood to Mr. Nicholson, 25th October 1785.

[139] *Ibid.*

[140] Moser, 'Why don't inventors patent?', 3, 25-26.

[141] Mokyr, *The Lever of Riches*, 250.

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

[143] Allen, 'Collective Invention'.

[144] Nuvolari 'Collective Invention'.

[145] *Ibid.*, 355; Allen, 'Collective Invention'.

[146] See note 101.