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Quality Standards and Travelling Facts in the British Wheat Markets of the Nineteenth Century

Introduction

During the nineteenth century the sources of wheat for the British markets changed significantly. This, coupled with organizational changes, changes in technology (transportation, port infrastructure, etc.), expansion of international trade routes (both in scale and scope), and the changing nature of the commodity, puts the spotlight on the importance of quality management in the wheat markets. One of the issues that the markets faced was how to capture facts about wheat quality *ex-ante* and how to make these facts travel effectively between the different market groups.

Generally, assessing quality of heterogeneous products such as wheat is difficult, as it is not practical to delineate all product attributes completely and generate facts about them.¹ Quality is a relative concept rather than an absolute one: it can have different meanings depending upon who is conducting the measurement. There is quality ‘in the eyes of producers’, but there is also quality ‘in the eyes of the consumers’.² To someone responsible for producing or inspecting a product, quality can be defined narrowly or absolutely. In contrast, to the user of that product, quality is a relative concept, to be compared with other similar or substitute products. Theoretically, this implies that facts about quality depend on the set of product attributes that a particular group chooses to proxy for the product’s quality. If attribute sets

¹ Yoram Barzel, "Measurement cost and the organization of markets," *Journal of Law and Economics* 25 (1982): 28-29; Stephen Craig Pirrong, "The efficient scope of private transactions-cost-reducing institutions: the successes and failures of commodity exchanges," *The Journal of Legal studies* 24 (1995).

² Peter Bowbrick, *The economics of quality, grades and brands* (London and New York: Routledge, 1992) 2-11.



differ amongst groups, then each group may generate different facts about the same commodity according to their different notions of product quality.³

In such a scenario, how 'well' could facts about wheat quality travel between different markets or different groups? The answer to this depends upon what we perceive to be travelling. In the context of quality management, travel could mean sharing particular information about the product, its composition, condition, functionality, etc. between groups who would otherwise have only partial access to such information. One way of making this happen is for all groups to make quality measurements using similar criteria using similar measurement artefacts and consistent practices, i.e. quality standards.⁴ This implies standardizing the attributes for assessing quality, developing standards to compare observations of selected attributes, establishing rules to sort products into different categories based on quality measurements, developing institutional rules and organizational structures to monitor the process, etc. This paper is an historical inquiry about whether such standards aided the travel of facts within the wheat markets in nineteenth century Britain, and the extent to which such facts about quality travelled. It explores the boundaries across which facts travelled and the elements that aided or inhibited the travelling.

Prima facie evidence suggests that different market groups developed their own individual criteria for evaluating the quality of wheat produce. Historically, samples of wheat would be assessed on the basis of numerous criteria, the assessment requiring a high degree of tacit knowledge and reliance on tactile senses (touch, smell, etc.).⁵ Literature suggests that with the advent of formal grading by commodity exchanges and trade associations in the latter half of the nineteenth century, product grading became the dominant way of conveying important

³ Barzel, "Measurement cost," 28-32, for a discussion of how buyers and sellers could sort commodities into multiple classes; Stefano Ponte and Peter Gibbon, "Quality standards, conventions and the governance of global value chains," *Economy and Society* 34 (2005): 7, for a discussion of quality from the perspective of 'convention theory'. They stress that 'there is no universal understanding of quality' and that 'quality is cognitively evaluated in different ways'; also, Benoit Daviron, "Small farm production and the standardization of tropical products," *Journal of Agrarian Change* 2 (2002).

⁴ Olivier Favereau, Olivier Biencourt, and François Eymard-Duvernay, "Where do markets come from? From (quality) conventions!," in *Conventions and structures in economic organization*, ed. Olivier Favereau and Emmanuel Lazega (Cheltenham, UK: Edward Elgar 2002), 243.

⁵ Stanley Dumbell, "The sale of corn in the nineteenth century," *The Economic Journal* 35 (1925): 144.



facts about wheat quality.⁶ But were wheat grades the only way in which facts about quality could travel between groups? How well did facts travel as a result of product grading?

This paper shows that there was no universal set of attributes that the markets used to measure quality even by the end of the nineteenth century. It demonstrates how quality assessment along the commodity chain involved the measurement of different sets of product attributes by different groups as the organization, technology and trade routes transformed and the number of 'standards' used to measure quality increased. It shows how different market groups developed different ways of capturing facts about product quality, which were not standardized across all market groups. As a result, I argue, that some facts travelled well across groups, but not all facts, and that the major barriers to travel were institutional rather than technological in nature.

The paper is organized as follows. The following section introduces the major issues that wheat markets faced in terms of quality in the nineteenth century. The subsequent three sections discuss quality management from the perspective of the trade or merchants, the major buyers of wheat (the millers), and the domestic wheat growers. The following section links these different perspectives in terms of quality measurements, wheat grades and standards and the institutions that developed them. Conclusions about quality and facts and how they travelled within and between market groups are offered in the final section.

Quality issues in the wheat markets

As the proportion of British population consuming wheat increased throughout the nineteenth century, the wheat trade underwent a significant change in composition and organization. Post-1860, more wheat was being imported than was being sold in the domestic markets: the

⁶ Pirrong, "Commodity Exchanges," 233; also Daviron, "Standardization of tropical products," for standardization of grades as a strategy to manage quality, although he admits that this is only 'one amongst a series of possible modes' to manage information asymmetry.

quantum of foreign imports was roughly eight times that of domestic sales.⁷ Imported wheat came from many sources, such as the US, Russia, Argentina, Australia, New Zealand, India, and several other locations in Europe. The structure of the trade had evolved since the eighteenth century and by the end of the nineteenth century involved a fairly complex organizational structure, characterized by layers of interrelated firms and organized commodity markets (figure 1).⁸

INSERT FIGURE 1 HERE

In the domestic markets, middlemen known as *corn factors* sold wheat in organized terminal markets, such as the Corn Exchange at Mark Lane in London. Very few farmers sold directly at Mark Lane and wheat was sold through the factors to millers or to shipping factors for re-shipment. Wheat that was not sent to London from the home counties, was sold to country millers, although it was not unusual for country millers to obtain wheat from London based factors.⁹ Although corn factors remained an important conduit for the trade buyers of wheat, the *importing merchant* became an important member in this chain as wheat imports increased. The structure of the trade at the exporting country became significant, particularly from the perspective of quality assessment, as we will see later on. Broadly speaking, wheat sold by the farmer to the *exporting merchant* for reshipment to Britain would normally arrive in sacks, which could be identified with the original seller. If grain was mixed it was done by the importing merchant at the port of import. The most important exception to this was North American corn, which was sold to the operators of the grain elevators. Here the grain would be mixed with other grain of similar quality, the farmer receiving the price according to the quality. The operators would sell this mixed grain, of 'standard' quality either at the trade exchanges or to the exporting or commission merchants at the large primary markets, such as Milwaukee or Chicago.¹⁰

⁷ In 1880, foreign wheat imports amounted to 55 million tons as opposed to 6.7 million tons reported in domestic returns; British Parliamentary Papers (hereafter *PP*) 1889 Vol. LX, *Statistical Tables of Corn Averages*, p. 423; *PP* 1886 Vol. LX, *Report of Grain Imported into the UK*, p. 405.

⁸ Morton Rothstein, "Multinationals in the grain trade, 1850-1914," *Business and Economic History* 12 (2nd Series) (1983).

⁹ C R Fay, "The London corn market at the beginning of the nineteenth century," *The American Economic Review* 15 (1925): 72-73; Dennis Baker, "The marketing of corn in the first half of the eighteenth century: North-east Kent," *Agricultural History Review* 18 (1970): 138.

¹⁰ Article in the trade journal, *Miller* (London), April 5, 1880, p 99; Rothstein, "Multinationals."



The trade dealt with numerous varieties of wheat grains, based upon botanical distinction as well as distinct characteristics of each botanical variety. By 1840 several new wheat varieties were added to the existing Red Lammas type of low yielding British varieties. At least 16 different domestic wheat types were available for sale in English grain markets in the 1850s, each differing not only in gluten content – the chemical substance which determines the bread-making ability of wheat - but also in terms of yield (i.e. quantity of grain per acre).¹¹ In addition to the domestic varieties, wheat imports greatly increased the total number of varieties available for sale in British markets. An analysis of English and foreign wheat available in 1884 listed more than 25 domestic varieties (including distinct grain types as well as grains of different quality) and about 40 foreign ones. The foreign varieties were used mainly in the manufacture of flour, particularly in South England.¹² Such heterogeneity was not unique in the wheat trade and is evident in other industrial commodities, such as cotton.¹³ On the whole, agricultural products were affected by several natural factors, and quality variations within the same variety or breed could occur in an unpredictable fashion. This made assessing their quality a particularly difficult process.¹⁴

An important issue here is at what stage in the long value chain was the quality of wheat measured and who measured it? Historically, it was in the interest of the mealman, who mixed different grades of wheat to get the ‘meal’ to bake bread, to assess the quality of grain he bought, as there was often a substantial price differential between the best and inferior quality wheats.¹⁵ When the millers integrated the functions of the mealman by the eighteenth century, the mixing of different grain quality, and therefore the assessment of quality, was done by them. With the establishment of the organized markets, such as Mark Lane or other regional markets, the assessment of quality was done at these nodes. This coincided with the

¹¹ John R Walton, "Varietal innovation and the competitiveness of the British cereals sector, 1760-1930," *Agricultural History Review* 47 (1999): 45-48.

¹² William Jago and William C Jago, *The technology of bread-making* (London: Kent & Co., 1911), 272-79.

¹³ Alonzo B Cox, "Relation of the price and quality of cotton," *Journal of Farm Economics* 11 (1929): 543; Alston Hill Garside, *Cotton goes to market : a graphic description of a great industry* (New York: Frederick A. Stokes Company, 1935), 46-67.

¹⁴ Wells A Sherman, "Standardizing production - what has been done and what can be done," *Annals of the American Academy of Political and Social Science* 142 (1929): 419.

¹⁵ Christian Petersen, *Bread and the British economy, c1770-1870*, ed. Andrew Jenkins (Aldershot, England: Solar Press, 1995), 158-9; *PP 1805 Vol. III*, p. 195, evidence of Peter Giles to the select committee stating that the price of good quality wheat could be double that of inferior quality.



rise in the practice of selling by sample. The buyer and the seller would agree on a price upon inspection of the sample and the delivery by the seller would have to conform to the quality of the assessed sample.¹⁶ When foreign grain was imported in large quantities after c1860, the inspection and sampling issues became particularly important to assess the quality of grain being imported, although their significance in earlier periods, especially for Irish imports, should not be underestimated.¹⁷ After c1860, grain imported from North America, especially from the Midwest area of the US, was shipped according to distinct quality grades. The grain elevator operators did the grading, particularly since grain from different producers was being mixed during storage and prior to transportation.

Broadly speaking, the nodes at which quality was measured changed and varied as the structure of the trade changed between the eighteenth and nineteenth centuries. Different groups developed their own individual criteria for evaluating the quality of produce and the degree to which it matched their requirements. Measurements were made some of the times at the exporting end, and at other times at the importing end of the trade. Why were the quality measurements made at different nodes along different trade routes? Why did different groups use different attribute sets to measure quality? To what extent did these practices inhibit the travel of facts about quality? Such issues are explored in more detail in the following sections.

Quality from the trade's perspective

Historically, samples of wheat sold in important markets such as London or Liverpool were submitted for inspection and the *natural weight* of the grain (i.e. its density or weight per cubic capacity), its colour, dryness, presence of impurities and other physical characteristics were important attributes on which quality was assessed. The extent to which tacit knowledge was used to assess quality was high as 'the eye, nose and hand were necessary [in] judging

¹⁶ Baker, "Corn marketing," 138; *PP 1834 Vol. XLIX* p. 259.

¹⁷ Dumbell, "Corn sales."



the value of grain and dealers could determine its specific gravity by “merely taking up and poisoning a small quantity of it in their hands”.¹⁸

In several domestic markets, selling on the basis of natural weight or density was a common method of assessing the quality of produce. This method guaranteed that the contracted volume of grain, say one-*bushel* measure, would weigh a specified amount, say 60 *lbs*. If the actual weight was more or less than the guaranteed weight per volume, the contract price was adjusted proportionately.¹⁹ For example, a contract for wheat from c1830, guaranteeing delivery weight to be 18 *stone* per *quarter*, specified price and terms as 54s 6d ‘pay or be paid’ i.e. the farmer was to make a ‘proportionate allowance’ to the merchant in case the net weight on delivery was under 18 *stone* 4 *lbs*, and conversely the farmer was to receive an allowance from the merchant in case the net weight on delivery was found to exceed 18 *stone* 4 *lbs*.²⁰ Also, wheat brought into Sheffield market from Gainsborough and Lynn was sold by the *quarter* weighing 504 *lbs*, whereas wheat from Hull was to be delivered at 480 *lbs* per *quarter*.²¹ There are similar examples from other market towns such as Lincoln, Stamford, York, Leeds, etc. The use of natural weights to assess the quality of wheat was not unique to Britain. French bakers regularly used this method to distinguish between good and average quality wheat.²²

Such natural weight measurements did not capture information about the *condition* of the grain, such as the presence of impurities, dryness or moisture content, texture, etc. – attributes that were equally important to the miller and the baker in addition to the composition of the grain. Historically, information about the condition of the grain could be verified through sampling and visual inspection. However, even inspecting samples proved to be problematic as samples sometimes hid the extent of variation in the quality of a given stock. For example,

¹⁸ Ibid. 144. It is important to consider the difference between *specific gravity* and *natural weight* in this context. Specific gravity measurements usually refer to the density of individual wheat grains. However, as will become clear later in the chapter, due to the manner in which natural weight measurements were made, they included the ‘density’ of empty spaces (or air) in addition to the density of the individual grain.

¹⁹ The other methods of selling grain in domestic markets were on the basis of volume-only or weight-only measures.

"Report from select committee on the sale of corn," in *PP 1834 Vol. VII*. Also, "Summary of returns by corn inspectors," in *PP 1878-79 Vol. LXV*.

²⁰ *PP 1834 Vol. XLIX*, p. 259; 1 *stone* equals 14 *lbs* and 6.35 *kgs*.

²¹ Ibid., 262.

²² Steven Laurence Kaplan, *Provisioning Paris: Merchants and millers in the grain and flour trade during the eighteenth century* (Ithaca and London: Cornell University Press, 1984), 52-3.



after selling on the basis of samples became common practice in the mid-eighteenth century, there were complaints against corn factors that they exposed only a selection of their samples so that the buyers did not get a complete picture of the actual quality of stock they represented. Sampling was also problematic in other commodity trades. Cotton sellers in Liverpool often accused brokers of carelessly handling samples, which ‘prejudiced the sale of the whole lot and often put the seller to the expense of re-sampling’.²³

From the mid-nineteenth century onwards, commodity exchanges, such as the London Corn Trade Association (LCTA) or the Chicago Board of Trade (CBT), began to develop detailed mechanisms to measure and grade these complex goods.²⁴ Developing grades involved selecting a finite set of characteristics, or ‘summary criteria’, such that the commodity could be graded into a manageable number of classes. Criteria used to determine the commercial grade of grain from the samples submitted for inspection included moisture content, natural weight, freedom from foreign material (cleanliness), condition and texture of the kernels, general condition (whether the grain is cool and sweet or it is musty, sour, heating or hot), etc.²⁵ Commodity exchanges initially found it difficult to fix numerical grading standards. When product attributes could not be graded absolutely or quantitatively, these exchanges provided an alternative by creating dispute resolution or arbitration mechanisms.²⁶ The commodity exchanges functioned as quality *assurance* or *guaranteeing* centres, and not only institutions that coordinated the measurement and grading activity.

The British exchanges, such as the LCTA and the Liverpool Corn Trade Association were primarily concerned with grading imported wheats, not domestic ones: there is no evidence that either of these exchanges developed formal grades for the domestic trade. By the end of the nineteenth century, guaranteeing quality of imported wheat traded in the London market involved four distinct grading methods: certificate final, sealed sample, fair average, and fair

²³ Daviron, "Standardization of tropical products," 169; Lowell D Hill, *Grain, grades and standards: Historical issues shaping the future* (Urbana & Chicago: University of Illinois Press, 1990), 6; Fay, "London corn market," 73; J C F Merrill, "Classification of grain into grades," *Annals of the American Academy of Political and Social Science* 38 (1911): 63; Thomas Ellison, *The cotton trade of Great Britain: including a history of the Liverpool cotton market and of the Liverpool cotton brokers' association* (London: E Wilson, 1886), 177.

²⁴ Pirrong, "Commodity Exchanges," 234.

²⁵ Lloyd S Tenny, "Standardization of farm products," *Annals of the American Academy of Political and Social Science* 137 (1928): 209.

²⁶ Pirrong, "Commodity Exchanges," 235.



average quality (FAQ).²⁷ The FAQ method was the one that was most commonly adopted in London. Under this method, samples of all grain imported into UK, including several ports in Europe, were periodically collected by LCTA who would then arrive at the grades for any given year. The actual mechanism or methods used to describe the grades could not be determined from the archival records. It is difficult to establish whether the FAQ grades were standards – as in a reference point that establishes conformity or deviation – or as ranked categories into which the different samples could be sorted. Since the grades were developed on a responsive basis, i.e. based on annual samples collected, it is likely they functioned as ranked categories rather than as standards.

When the LCTA began grading grain on the FAQ basis, the description of quality depended upon the source of the produce. For instance, when Indian grain was graded on FAQ terms, allowance was made for dirt and other impurities (such as non-farinaceous seeds).

‘[Not over] 3% of impurities of which 1(1/2)% may be dirt for shipments to the 30th June, and 3(1/2)% [impurities], of which 2% may be dirt, for the remainder of the seasons shipments’²⁸

Similarly, standards for New Zealand wheat were made separately for round berried and long berried wheat.²⁹ North American grain was gradually accepted on the basis of ‘official certificate of inspection to be final as to quality’, i.e. according to the quality guaranteed by the official inspection certificates issued in the US. Even so, LCTA would sometimes inspect the samples prior to accepting the grades.³⁰

While making the FAQ grades, the LCTA would take into account the differences in the natural weight of the grain from Argentina, Australia, California or other locations. For

²⁷ R B Forrester, "Commodity Exchanges in England," *Annals of the American Academy of Political and Social Science* 155 (1931): 202.

²⁸ London Corn Trade Association (LCTA), Minutes of East India grain committee: Vol. 1 (1888-96), entry for 8th Aug 1889.

²⁹ LCTA, Minutes of American and Australian grain committee: Vol 1 (1882-96), entry for 9th April 1891; John George Smith, *Organised produce markets* (New York: Longmans, Green and Co, 1922), 24-25.

³⁰ LCTA, Minutes of American and Australian grain committee: Vol 1 (1882-96), entry for 1st Jan 1891; Pirrong, "Commodity Exchanges," 236; LCTA, Papers of the Subcommittee to examine rules of arbitration, suggested alteration of Contract Forms 1898 proposed by the Liverpool Corn Trade Association on 8th Nov 1897 and accepted by committee.



example, while fixing the standard for Australian wheat in 1894, the LCTA fixed an average weight of 63 *lbs* per bushel for the seasons wheat. On the other hand, the average weight of Californian White was assumed to be 60.5 *lbs* per bushel, while fixing the standards for 1895. Similarly, for grain imported from the Black Sea ports, the committee had developed rules to account for the natural weight, especially for rye and barley.³¹ LCTA also used other criteria, such as cleanliness and colour, to establish its grades, as in the case of grain from India.

The use of natural weights is also evident in the case of the US wheat grades. In 1858, the Board of Trade of the City of Chicago (CBT) began classifying grades of grain according to descriptions of colour, quality and general condition and at the same time certifying to those grades.³² In 1859, CBT added 'test weight' i.e. natural weight, as a grading factor for wheat. The following minimum test weights (pounds per bushel) were introduced: Club, 60 *lbs*; No. 1, 56 *lbs*; Standard, 50 *lbs*; Rejected, 40 *lbs*. These did not always work, as in 1859 when grain less than 45 *lbs* per bushel but of Standard grade or better was delivered. As a result, CBT revised the grades and the minimum test weights as follows: No. 1, 56 *lbs*; Standard, 50 *lbs*; No. 2, 45 *lbs* and Rejected, 40 *lbs*. Even these 'standardized' natural weights failed to gain approval by the trade. The CBT consequently left the specification of the test weight to the discretion of the grain inspectors when ascertaining grade.³³

By the turn of the century, a numerical system of grading the various varieties of red, white, winter and spring wheat had emerged. For instance, No. 1 white winter wheat was defined as that which was pure white, sound, plump and well cleaned. No. 3 was defined as not clean and plump enough for No. 2 but which weighed not less than fifty-four *pounds* to the measured bushel. The Board of Railroad and Warehouse Commissioners had developed this system of rules for inspection in order to 'establish a proper number and standard of grades for inspection of grain'.³⁴ These rules took into account the natural weight of grains such as wheat, barley and oats to define certain grades in addition to other attributes.

³¹ LCTA, Minutes of American and Australian grain committee: Vol 1 (1882-96), entry Sep 24, 1895; Feb 20, 1894, etc.; LCTA, Minutes of Black Sea Grain Committee: Vol 1 (1890-1901), especially the comparative table for the regulation of the natural weight of rye; also, Forrester, "Commodity Exchanges," 202.

³² Merrill, "Grain grades," 58.

³³ Hill, *Grain, grades and standards*. 13-16.

³⁴ The forty-seventh annual report of the trade and commerce of Chicago published by the Chicago Board of Trade (Chicago, 1905), 30-33.



Nevertheless, the numerical grades in the US were not entirely based upon *quantitative* measurements of quality. Quantification of quality attributes continued to remain problematic and elusive. When the US Grain Dealers National Association adopted inspection rules in 1908, their Grade 1 specified moisture content to be 15%, impurities (dirt, broken grains, etc.) to be 1%. Yet in c1914, numerical grades continued to be based upon descriptions such as sound, dry, reasonably clean, sweet, mature, plump, etc.³⁵ Studies conducted by USDA after 1909 to identify ‘tangible factors’ influencing the ‘intrinsic value’ of corn considered weight per bushel as an important factor (apart from moisture, breakage, cleanliness, etc.). When the US Department of Agriculture (USDA) promulgated official grades for commercial corn in 1914, six distinct numerical grades were defined on the basis of moisture, damage to the kernels (due to heat or presence of broken corn, etc.) and presence of foreign material.³⁶

The foregoing discussion raises several issues regarding the measurement and management of quality in the British wheat trade. The first set of issues relates to the multiplicity of criteria used to define and measure the quality of wheat. Broadly speaking the density of wheat was considered as an important indicator of the bread-making ability of a given variety of wheat. Apart from density, other criteria were just as important in assessing the condition of the grain. Also, the set of attributes used to measure quality differed according to the trade route and sources of imported wheat.

The second set of issues relate to the difficulty in arriving at numerical standards of quality. Could the bread-making ability of wheat – an important test of grain quality of from a miller’s (and a baker’s) perspective – be quantified? What criteria should be included in this quantified measure? Understanding the buyers’ perspective of wheat quality will help to answer these questions.

³⁵ Hill, *Grain, grades and standards*. 76, table 3 comparing grades specified by USDA and those used in three major grain markets of New York, Chicago and Minneapolis.

³⁶ *Ibid.* 18-19 & 71-73.



The third set of issues relates to the nodes at which such measurements were made. For instance, why were quality measurements of American wheat, made in the exporting country? Why were they acceptable in British markets? Why was wheat imported from other sources checked for quality in British ports? These issues are explored in detail in the following sections.

Quality from the farmer's perspective

While the distinction between different wheat qualities was important, British wheat farmers were mainly concerned with the 'harvest index' of the crop. This index referred to the proportion of total shoot weight accounted for by the grain, the balance being the weight of the stalk (figure 2). To the farmer, both the grain as well as the stalk were of value, particularly in the high farming systems where the stalk provided valuable livestock fodder. In addition, there was an inverse relationship between the quantity of grain produced (yield) as opposed to its natural weight or density. Generally, varieties that had higher yields, in terms of volume per acre, had lower densities. Also, there was no single variety available that could produce heavy stalk yield and a large volume of grain at high densities preferred by the baking trade.³⁷

INSERT FIGURE 2 HERE

Grain yield was a multi-faceted concept to the farmer who had to balance all the three aspects of the harvest, i.e. the weight of the stalk, the weight of the grain and the total amount of grain produced. The application of high fertilizer doses in the nineteenth century, while increasing the overall yield of the crop, changed the character of the crop in one of two ways. If, the harvest index was reduced, that is the proportion of stalk to grain went up, this increased the density of the individual grains, while reducing its yield in terms of the total quantity of grain produced. But, if the overall quantity of the grain increased, i.e. the harvest

³⁷ Walton, "British cereals," 39-40.



index increased, it resulted in decreased density of the grains.³⁸ This quest for greater yield gradually resulted in a varietal shift of wheat available in domestic markets, as farmers preferred the high volumetric yielding varieties, but with lower density. These varieties of soft wheat began to replace the harder, lower volumetric, higher density yielding varieties previously grown.³⁹

For example, Talavera (originally introduced from Spain), a variety that offered a high flour extraction percentage and good quality flour, had a comparatively lower volumetric yield than another variety, such as Spalding, which had lower bushel weight and higher volume yields. By the 1860s, Talavera was largely abandoned by farmers, whereas Spalding, ‘a farmer’s wheat than a miller’s’, was extensively grown.⁴⁰ Thus, we see a dissonance between the preference of the farmers and large buyers of wheat: millers complained that they could not find suitable domestic wheats for bread-making. This varietal shift implied that the softer high yielding wheat increasingly grown in Britain after c1860 were unsuited to the rolling mill technology introduced in the 1880s and millers had to import hard wheats that were more suited for this new technology.

The foregoing demonstrates that different market groups held different notions of good, as opposed to unsuitable, grain quality. These different notions of grain quality arose due to the different sets of attributes that the producers and buyers of wheat used to assess quality.

Quality from the buyers’ perspective

While important changes were occurring in the British wheat trade in the latter half of the nineteenth century, there were corresponding and equally significant changes in the milling industry around the same time. Being one of the largest buyers of wheat, these changes cannot be merely coincidental and were intimately connected. The important question here is

³⁸ Ibid. 39-40 & 48.

³⁹ Ibid. 48-50.

⁴⁰ Ibid. 48-51.



how did the millers assess wheat quality and what problems did they face in measuring or quantifying quality.

After c1870, we discern a ‘professionalization’ of skills required in the milling industry as the process of milling became highly specialized and technically sophisticated. This is evidenced by at least two developments that have a direct relevance to the issues discussed here. First, in this period we witness some radical changes in the methods, locations and reorganization of the milling industry that stem from revolutionary technological advances made after c1870, primarily the introduction of roller milling technology. The main advantage of this new technology was that it improved the quality and the whiteness of flour obtained for the same proportion of grains used to produce the coarse ‘household’ grade flour using the older grinding technology.⁴¹ The speed and extent of adoption of roller milling was shaped by at least three important factors: increasing domestic demand for white flour, unsuitability of softer domestic wheat varieties, and increase in the imports of foreign flour and hard wheat varieties. Second, we also see the emergence of some institutions in this period that further engineered the professionalization of the trade. These institutions included technical and trade journals, and industry associations that sought to overcome the knowledge and skills deficit within the industry. The structural reorganization and institutions helped to modernize the milling industry.⁴²

Consequent to these changes, the manner in which grain quality was assessed, the quality attributes of grain that were considered important for making flour of a given quality, and the manner in which they were measured were re-examined and refined. It was generally acknowledged that ‘the value to the miller of a certain variety of wheat depends upon the quantity of fine flour it will yield.’⁴³ Wheat of least specific gravity was known to yield a lower quality of flour and vice versa. ‘More flour is produced from corn of higher specific gravity, and more bread from such flour, than from inferior corn or inferior flour’, a

⁴¹ Richard Perren, "Structural change and market growth in the food industry: Flour milling in Britain, Europe and America, 1850-1914," *The Economic History Review* 43 (1990): 423.

⁴² H Macrosty, "The grainmilling industry: A study in Organization," *The Economic Journal* 13 (1903); Glyn Jones, *The millers: A story of technological endeavour and industrial success, 1870-2001* (Lancaster: Carnegie Publishing Limited, 2001), esp. Chap. 1; Perren, "Flour milling."; Jennifer Tann and Glyn Jones, "Technology and transformation: The diffusion of the roller mill in the British flour milling industry, 1870-1907," *Technology and Culture* 37 (1996).

⁴³ *Miller*, May 5, 1879, Technical Issue, p. 193.



parliamentary report from 1834 had claimed.⁴⁴ Although lighter, coarser grains could yield a larger proportion of flour. This was achieved by including coarse bran and thereby reducing the quality of flour obtained.⁴⁵ Generally, the millers, and bakers, preferred wheat varieties with high natural weights to the 'softer' wheat varieties with lower densities.⁴⁶

But it wasn't only the density of the grain that was important to the miller: the 'strength' of the grain or flour was crucial to the miller (and the baker) as well. Strength was initially defined as the ability to absorb and retain moisture, which later was modified to indicate the quantity and quality of gluten the grain contained.⁴⁷ Stronger flour was preferred because the number of loaves obtained from a given weight of flour were more than those obtained from weaker flour.⁴⁸ Hard wheat of the low yielding (and conversely high density variety) were considered to be stronger wheats, whereas softer wheats were considered to be of the weaker kind. British wheats, on the whole, were considered to be of the weaker kind.⁴⁹ The miller basically had to balance both the density as well as moisture characteristics of the grain, as those varieties with the highest-bushel weight with low moisture content usually gave the greatest amount of flour.⁵⁰

One of the greatest skills that a miller had to possess was to know which varieties of wheats to process and mix together as 'grist'; i.e. flour that the bakers would accept as being of consistent quality. Flour itself could be graded into different types: whites, firsts (or best households), seconds (or second households or standard wheaten), thirds (third households or fine middlings), fourths (or coarse middlings or sharps), and wholemeal.⁵¹ Millers scarcely recognized a consistent system of grading flour, however, each flour grade required a different quality of grain.⁵² Mixing of different wheat qualities also allowed the widest possible use of inferior grade of wheats, which by themselves would have been unsuitable for making baking flour, particularly in London and other larger towns. Mixing also eked out the

⁴⁴ Report from select committee on sale of corn, *PP 1834 Vol. VII.*

⁴⁵ *Miller*, May 5, 1879, Technical Issue, p. 193; Nov. 3, 1879, p. 682.

⁴⁶ Walton, "British cereals," 39-40.

⁴⁷ Jago and Jago, *Breadmaking*, 291; also, Jones, *The millers*. 60.

⁴⁸ John Percival, *Wheat in Great Britain* (Reading, 1934). 69.

⁴⁹ *Ibid.* 71.

⁵⁰ *Ibid.* 72; See also Jago and Jago, *Breadmaking*. 369; Jones, *The millers*. 59-60.

⁵¹ Petersen, *Bread and Britain*. 53-54.

⁵² J Kirkland, "The relative prices of wheat and bread," *The Economic Journal* 6 (1896): 479.



supply of expensive best quality wheat, and enabled the miller to enhance his margin by mixing expensive and inexpensive wheats and still sell the mixed flour at a price higher than that of inferior quality flour.⁵³

A typical mixture recommended in the eighteenth century included one part best quality wheat to one part second-best quality wheat to two parts inferior quality wheat.⁵⁴ Such a mixture implied a price ratio of about 100:91:81 for best, second and inferior quality wheat respectively.⁵⁵ As the availability of foreign wheat increased, best quality imported wheat was mixed with lower quality domestic varieties.⁵⁶ Wheat imports greatly increased the choice of wheat available for the miller to mix in various proportions, vastly increasing the complexity of the mealing process. By the latter half of the nineteenth century, millers required knowledge about the varieties available, its sources, and quality. The miller's craft had begun to demand a great deal of experimentation and risk. Millers had to consider, for each variety of wheat, whether it would contribute to one or more aspect of flour quality: strength, colour, taste or general appearance. Consequently, wheat buying was governed by experience, general principles and a considerable degree of detailed knowledge, and no two millers agreed on what constituted good quality.

For instance, one miller invited comment on whether the following mixture 'ought to make a good sack of bakers flour': 3 sacks red winter; 2 sacks Michigan; 2 sacks No. 2 spring and 5 sacks of English white.⁵⁷ He received at least five suggestions from other millers – all different. One correspondent suggested that the proportion of English wheat was too high and instead recommended that 3 sacks of Michigan be used instead of 2, and that English white be limited to 2 sacks. Another correspondent suggested the original mixture would result in 'lack of strength and colour' and suggested eliminating English white altogether and adding

⁵³ *PP 1814-15 Vol. V*, p1353, evidence by E G Smith; Petersen, *Bread and Britain*. 158-9.

⁵⁴ Petersen, *Bread and Britain*, 159; Historically, wheat had been divided into 'best', 'second' and 'third' quality categories according to some quality attributes for the purpose of setting the Assize of Bread, 12 Henry VII cited in *PP 1814-15 Vol. V*, p. 1344.

⁵⁵ Petersen, *Bread and Britain*, table 6.2 on 160. The average prices in the table have been calculated from evidence provided to the Select Committee on Sale of Corn by Richard Page, *PP 1834 Vol. VII*, p356. These are unweighted averages and weighting them with the mix proportion suggests an average price of 88 for the grain mix compared to the relative prices of individual grain qualities.

⁵⁶ Petersen, *Bread and Britain*; *PP 1834 Vol. VII*; *PP 1814-15 Vol. V*, various testimonies.

⁵⁷ *Miller*, Feb 2, 1880, Letter no. 669, p. 922.



an extra sack of No. 2 spring to the mixture: alternatively, the red winter, No. 2 spring and the English white could be mixed in equal proportions. A third correspondent suggested leaving the English white out altogether, grinding the remaining mixture separately, and then letting the meal sit in the sack for a few days before mixing. The fourth correspondent suggested that if this was milled in the country then 6 parts each of No. 1 American spring with 'sound' new English white wheat, mixed well in a bin a week before grinding, could give the desired results. The fifth correspondent recommended one sack each of Dantzic and American spring, three sacks each of American white and American winter and four sacks of English white (part new and part old).⁵⁸ Thus, there was dissonance amongst the millers as to the quality differences between the various varieties and quality was a relative rather than an absolute value in this industry.

Mixing of different flours and getting the quality of the wheat was important since a direct volumetric relationship existed between grain inputs and flour output. Consider this example from more recent times. The Chicago CBT specified grade number 2 soft red winter wheat (SRW) uses a 58 pound per bushel as criteria. A miller usually bases grain price to flour ratios on the assumption of a 73% flour extraction rate, implying that 2.36 bushels would be required to produce 100 pounds of flour. A reduction of weight from 58 pound to 57 pound per bushel has two implications. First, at the same extraction rate, the miller now needs 2.40 bushels of wheat to produce 100 pounds of flour. Second, a reduction of weight, and hence quality of the grain, is likely accompanied by a reduction of extraction rate to say 70% which further increases the quantity of grain required, 2.50 bushels, to produce the same quantity of flour. The resulting cost differential of wheat to flour is not always reflected in the price discounts for the different wheat qualities.⁵⁹

Of course, to the British miller in the late nineteenth century it was not only the price of individual variety of wheat that was of ultimate importance, but the relative costs differentials between the individual varieties due to the blending of flours. The miller had to balance his

⁵⁸ Miller, Letters: reply to 669, Mar 1, 1880, p. 45-46; Apr 5, 1880, p. 119; See also Kirkland, "Bread prices," 481, for yet another example of grist mixture.

⁵⁹ Eluned Jones, "The role of information in US grain and oilseed markets," *Review of Agricultural Economics* 21 (1999): 250-251.



margins according to the price of bread and the price of wheat. Comparing the price of flour to the price of bread and wheat over a 52-week period between 1894 and 1895, we see the degree to which the millers had to manage this balancing act. Figure 6.7 compares the price of wheat to flour assuming that the following mixture of grains is used to make the grist: 30% each of No. 1 Spring American and Fine Russian and 20% each of Red Winter and Fine English. Moreover, millers were often forced by competition to sell flour at less than its value as compared to wheat or to the corresponding quality of the flour to make its price remunerative.⁶⁰

The foregoing discussion highlights the particular meaning of wheat quality to the miller. As the milling process became more specialized and sophisticated, the *differences* in quality between varieties as well as the *consistency* of quality in a given variety became crucially important. Managing wheat quality was necessary to achieve the desired quality of flour, and to enable the millers to remain profitable. How did the millers measure the quality of grain?

Throughout most of the nineteenth century millers relied upon the visual inspection of samples to purchase grain, the attributes of relevance being the density, colour, texture, and the extent of cleanliness. When the volume of imported grain increased and the number of varieties available multiplied, the millers, like the merchants, began to rely upon the grades and standards set by the various commodity associations, such as the LCTA or the Liverpool Corn Trade Association. The correspondence between millers presented above regarding the different varieties and grades of wheat is indicative of this shift. We discern a trend of shifting reliance from visual inspection and assessment of quality to a gradual acceptance of the grading and standards developed by the various commodity associations. Millers purchasing domestic grain continued to do so based on older techniques of visual inspection and natural weights, although the importance of domestic wheat had diminished by the twentieth century; only about 19 percent of home grown wheat was used for bread making by 1914, down from 60 percent in c1860.⁶¹

⁶⁰ Kirkland, "Bread prices," 481-2.

⁶¹ Perren, "Flour milling," 425, table 1; Jones, *The millers*, 59; Percival, *Wheat*. 71.



Notwithstanding this shifting reliance on grades, assessing the quality of grain still depended upon the ‘empiricism of the practical miller’.⁶² The following extract from *The Miller*, c1875 is illustrative:

‘In purchasing wheat and choosing the description necessary to secure a uniform brand of flour, millers must often feel the want of a reliable test to guide them. It requires a very long and constant experience to judge the quality of even those wheat appearing daily in our markets; but we are left with the most unpleasant uncertainty when new descriptions are introduced to our notice.’⁶³

By the last quarter of the nineteenth century, techniques for assessing the quality of wheat were still fairly uncertain. One expert wrote in 1890 that ‘it will be well for mixing purposes to consider wheat as coming under one of three heads – strong, coloury or neutral (*sic*)’.⁶⁴ He further pointed out that wheat buying was governed by experience, general principles and by what varieties of wheat happened to be available in supply. After 1880, changes in milling technology were accompanied by development and improvements in testing and measuring the different quality attributes. The increased understanding of the chemical composition and properties of gluten, the substance in grain that lends strength to the flour, aided these developments. Various testing methods and instruments were made available for assessing the quality of flour: Pekar’s method of assessing whiteness of flour, Boland’s aleurometer to test the strength of gluten, and Robine’s method for estimating quantity and likely bread output are some examples.⁶⁵ Even so, each miller had to discover for himself the strength of any given flour, as there was ‘no satisfactory method of numerically registering strength except through a baking test’.⁶⁶

To summarize, the milling industry, towards the end of the nineteenth century required more sophisticated ways of assessing the quality of wheat compared to the relatively crude test of natural weight measurements and visual inspection – methods largely used by the trade to

⁶² Jones, *The millers*, 61.

⁶³ *Miller*, Oct 4 1875, ‘The study of a method to meet the requirements of millers in the analysis of wheat and wheaten flour’, p 196-7.

⁶⁴ W R Voller, *Modern flour milling*, Gloucester, 1889, as cited in Jones, *The millers*, 59.

⁶⁵ *Ibid.* 59-61.

⁶⁶ Jago and Jago, *Breadmaking*, 291; also, Jones, *The millers*, 60-61.



grade grain quality. The millers sought to capture the grain composition in more explicit terms of gluten and protein content rather than the simplistic notion of density. The millers were beginning to rely upon the grades established by LCTA to assess the condition of grain reaching Britain. This was an iterative process with the grading of quality helping the milling industry to become more professional, which in turn, and in conjunction with other changes in the industry, required further refinement of the quality grades themselves. The industry thus played an important role in the standardization of *ex ante* assessment and guaranteeing of wheat quality based on its composition and condition. Even so, assessment and testing on the basis of performance criteria remained the miller's responsibility. The millers had to rely upon baking tests and other measurements to ascertain quality *ex post*.

Measurements, Standards and Travel

The foregoing discussion highlights several aspects of how different groups sought to measure and manage quality and, consequently, how facts about quality travelled within and between the groups. We have seen how the British farmers and millers favoured different quality attributes of the wheat grain. To the farmers, the composition of the grain was important in terms of its density; the lower the density of the individual grain, the higher the quantum of the yield obtained by the farmers. The composition of the grain was also important to the millers. However, they preferred the density of the grain to be higher, as it increased its bread-making ability. In addition, the millers were also concerned about other compositional attributes, such as colour, shape, and texture, as well as the condition of the grain. Practically, grain with certain 'undesirable' attributes, e.g. high moisture content, high impurities, etc., could be corrected and re-sorted into higher grades. But, grain with undesirable compositional attributes could not be corrected for.

When the merchants began grading wheat, they were based on several compositional and conditional attributes, including natural weight, moisture content, cleanliness, and other descriptors (such as long or round berried for New Zealand corn. The Liverpool Corn Trade Association (LvCTA) began establishing 'contract grades' of wheat after c1855, which



differed somewhat from the LCTA.⁶⁷ However, by the end of the nineteenth century, Liverpool merchants were content to use the grades established by the LCTA.⁶⁸ The grades so developed were primarily for wheat imports from East Europe, Australia, South America or India. Imports from the US, with the exception of California, were graded at source and were accompanied by certificates of quality by institutions such as the CBT. Why was US wheat graded at source, while wheat from other sources was graded in the UK?

The elevator-based storage system that developed in America in the latter half of the nineteenth century enabled formal grading, and in fact required it. The grain (wheat) was graded at the point when the farmer brought it for storage at the shipping point. The elevator agent upon examining the quality of the grain settled with the farmer both the grade of the grain and its value. This grain was stored in the elevator along with grain of similar quality, thus segregating the identity of the grain parcels from that of the individual sellers. The seller (farmer) received value according to the lowest quality that the grain could be graded into. This strengthened the incentives of those shipping the grain to elevators to maintain quality before storage.⁶⁹ Once the graded grain was loaded onto ships or railway cars for transport it was nearly impossible to mix grain of varying qualities. Such opportunism problems and malpractices were possible prior to storage.

In contrast, handling facilities for grain imported from other countries such as Argentina and Australia were extremely crude. Crude handling methods exposed the grain to varying weather and insect condition and the absence of elevators meant that it was most efficient to ship grain in bags. This made it virtually impossible to create parcels of grain of standardized grades by combining grain from individual growers prior to shipment, as was possible in the elevator based storages of North America. Further, with individual shipments retaining their identity, inspecting quality at the importing country economized on the number of measurements necessary along such a trade route. There were few incentives to prevent dissipation of quality prior to bagging and storage. But all things being equal, this system

⁶⁷ Forrester, "Commodity Exchanges," 203.

⁶⁸ Minute books of the LCTA, Guildhall Library.

⁶⁹ Pirrong, "Commodity Exchanges," 237; James Stewart, "Marketing wheat," *Annals of the American Academy of Political and Social Science* 107 (1923): 187-188.



would have given the shipper an incentive to take care of the cargo at sea.⁷⁰ In such practices quality could not be guaranteed prior to shipment. The FAQ system, an *ex-post* method of grading, was particularly suited in these instances. It adjusted standards to reflect systematic factors affecting the quality of grain from a particular location (level of quality due to grain composition as well as condition due to storage, transport, handling, etc.), and made fewer quality distinctions between different shipments. The method minimized the number of potential disputes regarding product quality.⁷¹

Why did the British buyer trust the LCTA (or CBT) grades? The grades developed by the commodity associations took into account the composition as well as the condition of the wheat grains. Earlier, buyers had had to rely upon visual inspection of samples to ascertain condition, potentially leading to disputes if the delivered stock did not conform to sample. Additionally, the associations that developed these grades functioned as quality assurance and dispute resolution centres, apart from aiding in the assessment and measurement of quality. Dispute resolution by arbitration became widespread in the latter half of the nineteenth century as the corn trade associations set up transparent resolution mechanisms. Mostly, disputes regarding the quality and condition of grain 'occupied the time of arbitrators.'⁷² Also, British associations helped to address quality problems concerning US graded grain by raising these issues directly with CBT or other exchanges.

In addition to the ability to resolve disputes over quality, the membership policies of some of these associations also gave credence to the grades. For instance, the arbitrators appointed by the LCTA in case of disputes would include millers in addition to merchants and corn factors, ensuring that buyers as well as sellers were represented in the process. At times, the National Association of British and Irish Millers (NABIM) was also involved in the process of setting grades and often made suggestions to LCTA on quality standards.⁷³

⁷⁰ This would also have depended upon the contract and shipping terms, i.e. who had the residual property rights on the cargo and who paid for insurance, freight, etc.

⁷¹ Pirrong, "Commodity Exchanges," 238-39.

⁷² Robert B Ferguson, "The adjudication of commercial disputes and the legal system in modern England," *British Journal of Law and Society* 7 (1980): 145; C Chattaway, "Arbitration in the Foreign Corn Trade in London," *The Economic Journal* 17 (1907).

⁷³ LCTA, Papers of the Subcommittee to examine rules of arbitration, entry for 1896.



But grading was not the only way of capturing and communicating facts about the wheat's quality. Coinciding with the increased role of third party organizations, there were technological changes, such as the introduction of newer testing methods for wheat quality, and the development of instruments that could measure the density of grain directly, such as the chondrometer or grain-tester.⁷⁴ Changes in milling technology, science (primarily in chemistry) and education also influenced quality measurement practices. Scientific study of the wheat grain and the nutritive value of its different parts focused on understanding the chemical and physical properties of its proteins, especially gluten.⁷⁵ An increased understanding of the chemistry of wheat and advances in testing increased the sophistication of quality assessment techniques in comparison with the relatively crude and unreliable estimation of quality using natural weight measurements. This was accompanied by an increased effort to educate millers in the 'science of milling'. The NAIBM organized meetings, presentations, symposia, technical classes, etc. to increase the awareness of these methods and further the practical requirements of retraining mill staff.⁷⁶ The millers had begun to use the terminology of the grades. Nevertheless, they continued to test the grade quality independently, governed by experience as well as new science of milling and bread-making.

What was the significance of these trends? The complexities involved in the quality assessment and control were managed through the involvement of third party organizations by the end of the nineteenth century. This was a form of coordination that the market adopted to make the monitoring and guaranteeing of quality more manageable and effective. But, different groups developed different methods to capture different aspects of the product's quality, i.e. its compositional, conditional or functional aspects. There was no unique way of capturing information about the products quality and this was reflected in the different practices by the millers (buyers) and the trade (sellers). There were differences in quality assessment practices between different groups of traders: US sellers versus rest of the exporting countries, domestic versus importing merchants, etc. This meant that the British

⁷⁴ *PP 1890-91 Vol. XII*, p. 54-56.

⁷⁵ Harriette Chick, "Wheat and bread: A historical introduction," *Proceedings of the Nutrition Society* (1957): 3; Jago and Jago, *Breadmaking*. 272-273 & 369-370.

⁷⁶ Jones, *The millers*. 150-156; Tann and Jones, "Technology and transformation," 68.



wheat markets did not use standardized practices across all trade routes as far as quality measurements were concerned. The attributes measured, the standards used, the measuring instruments and the measurement protocols all seemed to vary. This is not to imply that few standards existed – on the contrary, we detect an increase in the use of many different kinds of standards (product grades, instruments, metrological units, etc.). Coordination between these various practices – and as a consequence the circulation of facts about quality - was conditioned by market institutions and third party organizations.

Conclusions

In this paper we have seen that although general facts about quality travelled well between different groups in the wheat markets, particular facts tended to have a well-defined range of travel. Virtually all groups associated high quality with high density of the wheat grain. However, beyond this general fact, each group valued different facts about specific product attributes, be they compositional, conditional or functional in nature. Consequently, the groups developed different practices to capture the particular facts they valued most. Travel of these particular facts beyond the group's boundaries depended upon many other institutional factors.

This leads to an interesting observation that that although general facts about quality travelled within the markets, the 'wellness' of travel depended upon the extent to which different groups reconciled them in the context of particular facts they themselves had captured. In other words, whether a particular variety of wheat was generally held to be of high quality by millers depended upon how they could establish that variety's quality in the context of the attributes they valued most, be it density, strength, smell, etc.

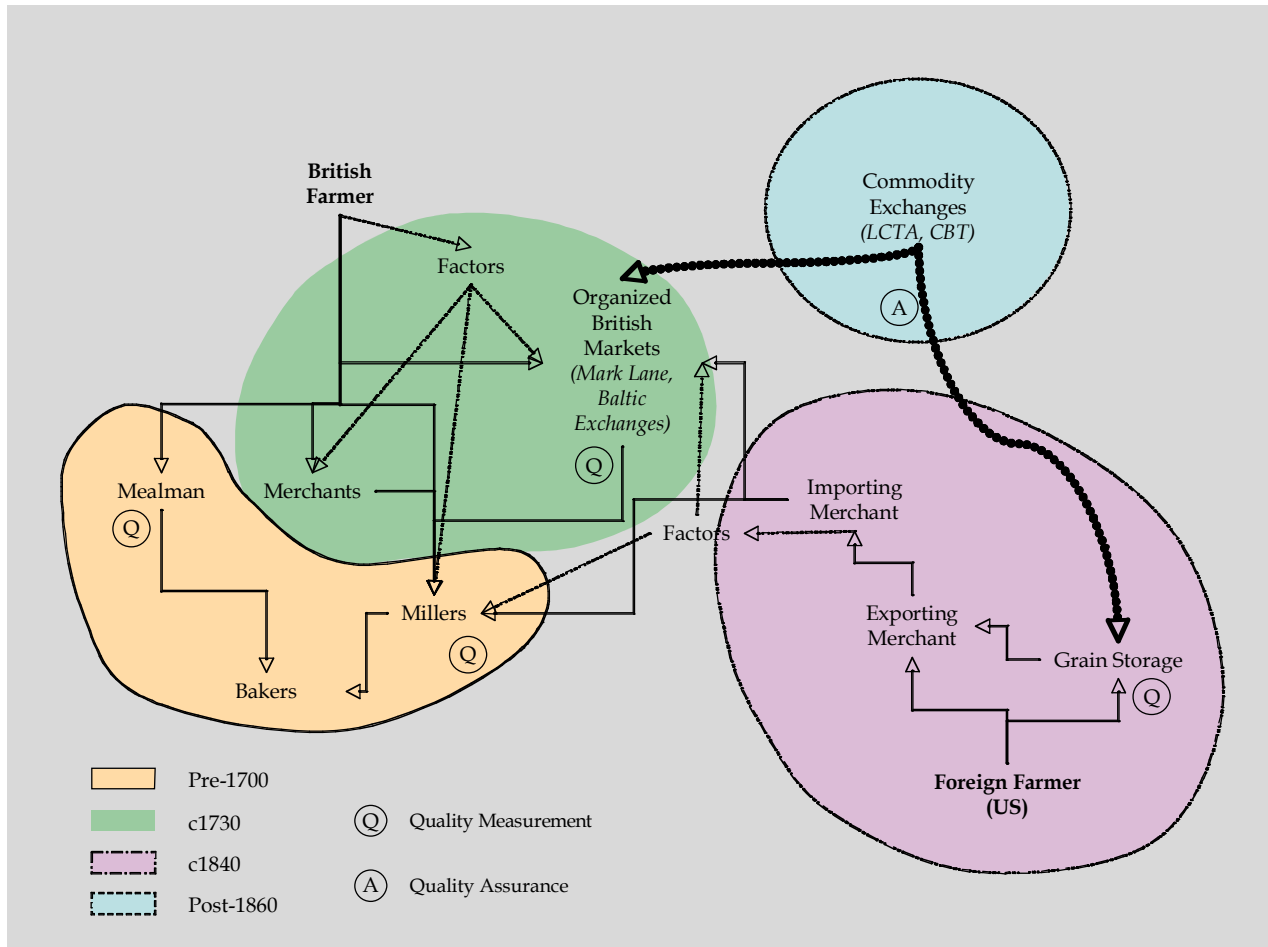
Institutionally, attempts to make particular facts immutable and portable by attaching labels are reflected in the attempts to grade different wheat varieties by the commodity associations. Such labels aided the travel of facts (and also the trade in those varieties), particularly over long distances; they helped to reduce transaction costs by reducing information costs.



Particular facts, along with such labels, travelled along with the commodity from the originating ports to the destinations in many cases. In other cases, these labels had to be developed at the destination ports, which in turn enabled particular facts (and the commodity) to travel from the merchants to the buyers. The important observation here is that the trust in these labels depended upon the institutional context in which they were developed. Trust did not depend upon whether they were numerical or quantified.

Even so, labels (in the form of grades or quality standards) were not sufficient to make facts travel. There is thus no evidence of 'true' facts about quality that were circulating within the wheat markets. There were no overriding facts about quality that travelled well within and between different groups, despite the increase of standardization and product grading. Facts about quality were made up of numerous particular facts that different groups valued in different ways.

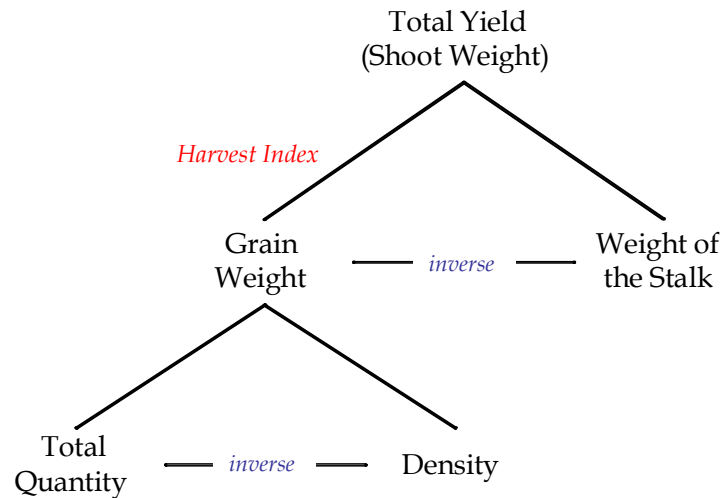
Figure 1



Source: See text

Figure 2

Components of Yield in 19th Century Grain Varieties



Source: Based on Figure 1 in Walton, "British cereals," 39-40 & 48.



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