

Technical Change in the Brewing Industry in Germany, The Low Countries, and England in the Late Middle Ages

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Brewing in late medieval northern Europe went through a series of changes which transformed it from a small, largely domestic industry to a large-scale one with growing output, producing for the international market. The changes were most dramatic in Holland, where at its peak, brewing may have had up to 5% of the total population working in the trade in the late fifteenth century. In the 1480s the town of Gouda alone boasted an output which averaged over 26,000,000 litres per year, a sharp contrast from a century before and from many other towns which were larger. It would be wrong to suggest that there is a single typology of change in the transformation of late medieval brewing. Efforts in the past to generate universal stage theories of technical advance have failed when faced with the complexities of such developments and with the many factors, internal and external, which have an effect on the adoption of technology. On the other hand, though changes in brewing do not have a universal form, there was something of a consistent pattern in the different parts of northern Europe as each went through the process of taking on a new method of making beer. The pattern of change falls into six loosely-defined phases or periods, what would in the nineteenth century have probably been called stages. First, there was a period of preparation typified by development of a market for the good and development of a production base. Second, there was the introduction of a superior product, a variant on the original, based on some technical change in how the good was made. Third, there was a

shock from some external source, and sometimes a sharp shock, which promoted the introduction of the product innovation. Fourth, there was a period of acclimatization of the new technique to local conditions and acclimatization of local markets to the new variant product. Fifth, there was a full mastery of the new technology by local practitioners, yielding an industry which can be called mature. Sixth and last, there was a period of process innovation where, by improving ways of making the variant good, producers found ways to exploit fully the opportunity created by the product innovation. Those six different phases appear, admittedly in differing degrees, in late medieval brewing in north Germany, Holland, the southern Low Countries, and in England. Though the extent and quality of evidence varies, and varies greatly, from place to place it is still possible to trace the pattern of change and, in some cases, to follow changes in the volume of production which can serve as indicators of the pace of technical advance.

I

In the first phase, the phase of preparation, there was a long-term spread of brewing to all parts of northern Europe. By the high Middle Ages, brewing existed in many if not most homes. Practice there was consistent with what went on in the countryside well into the nineteenth century. Ethnographic evidence from Scandinavia, for example, reveals a well-established tradition of rural beer-making.¹ English tax records, for example, show that brewing was almost universal throughout the kingdom. The Assize of Bread and Ale, which dates from the thirteenth century and the reign of King Henry III, led to innumerable householders in villages in effect paying a tax for the pri-

¹ ODD NORDLUND, *Brewing and Beer Traditions in Norway The Social Anthropological Background of the Brewing Industry*, Oslo: Universitetsforlaget, 1969. MATTI RÄSÄNEN, *Von Halm zum Fass. Die volkstümlichen alkoholarmen Getreidegetranke in Finnland*, Helsinki, 1975.

vilege of making beer when they were fined for violation of that law.² Domestic practices were copied by religious establishments but usually on a larger scale. Monasteries throughout northern Europe brewed beer for both residents and guests, quantities depending on the size of the institution. At least in the Low Countries and the Rhine Valley beer was made with *gruit*, a mixture of dried herbs made up largely of bog myrtle. Since the ingredients for *gruit* were hard to find governments took over control of supplies and then taxed the use of *gruit*. The emperor, or more often his representative, granted the right to use *gruit* to monasteries in exchange for a fixed payment. By the thirteenth century such grants were going not only to religious houses but also to laymen and to town governments.³

Urbanization throughout northern Europe in the eleventh and twelfth centuries, first in Flanders and then in England and north Germany as well as in Holland created new opportunities for commercial brewing. Some farmers, or more typically their wives, had for some time sold surplus beer to neighbours and even to buyers in other villages and towns. In the new and growing towns specialist brewers emerged whose principal if not sole occupation was making beer and selling it to other urban residents. The relatively more crowded conditions of urban life meant that often there was no room in houses for domestic brewing as there was in the countryside. Specialization allowed brewers to learn from experience and also to invest in more or better equipment, such as copper brew-kettles. The professional brewers could make better beer and also decrease spoilage so cutting down on losses. That contributed to their ability to compete with if not completely to replace domestically brewed beer in towns. By 1300 in northwestern Europe there

² L.F. SALZMAN, *English Industries of the Middle Ages*, New edition, enlarged and illustrated, London: H. Pordes, 1964. (First edition, 1913), 287.

³ ALOYS SCHULTE, "Vom Grutbiere: Ein Studie zur Wirtschafts- und Verfassungsgeschichte", *Annalen des historischen Vereins für den Niederrhein*, 85(1908), 132-43. C. VAN DE KIEFT, "Gruit en ban", *Tijdschrift voor Geschiedenis*, 77 (1964), 158-68.

was an urban brewing industry, the breweries in towns producing beer for a commercial market. A distribution network was in operation and there were regulations at various levels of government covering production and selling. Consumers had become familiar with and used to beer, beer of a certain type. While in the Rhine Valley beer was flavoured with *gruit*, there is no mention of that particular combination of herbs in England, for example. There all kinds of additives were used as in Scandinavia, northeastern Europe and for that matter throughout the countryside where domestic brewers were aware of a variety of different possibilities. Even though there might be different flavors of beer there was still a market for the product, a market prepared to accept variant types and with the necessary structure to absorb different types of beer.

II

The second step in the process was the introduction of a superior variant of the existing product, in this case beer made with hops. The change came first in port towns in north Germany. There in the twelfth century some brewers went over to adding hops to their beer. Hops is a Ural-Altaic word so the plant may have come to Europe from Central Asia. The plant was grown in gardens by the eighth century and by the twelfth towns in north Germany had special plots for growing the herb.⁴ It was there that brewers first began to use hops but no account of how, when or, why it came to pass has survived. Records for the period are sparse and, as well, contemporaries presumably did not perceive the event as unusual. It is fair to assume that hops was just one additive among many. When used

⁴ WALTER HORN and ERNEST BORN, *The Plan of St. Gall: A Study of the Architecture and Economy of, and Life in a Paradigmatic Carolingian Monastery*, Berkeley: University of California Press, 1979, vol. II, 261-63. For example, FRIEDRICH TECHEN, "Das Brauwerk in Wismar", *Hansisches Geschichtsblätter*, 21 (1915), 263-66.

in the right quantities and under the best conditions hops proved to give certain real advantages. It is certainly likely that brewers did not appreciate those real advantages immediately.⁵ Over time, however, they gained mastery over the use of hops. By the late thirteenth century first Bremen and then Hamburg were exporting hopped beer.

Hops simply replaced *gruit* or any other flavoring in the brewing stage. Because of the presence of certain oils in hops the resulting beer could last longer without spoiling. It was more difficult for bacteria to grow or survive in beer made with hops. Beer formed the ideal medium for the growth of all kinds of micro-organisms and bacteria were the source of unwanted deterioration in the drink. In the absence of hops the way to contain bacterial growth was to raise the alcohol content. So beer with hops then could be less strong than its predecessors. The alcohol level of beer is dependant on the quantity of sugar in the liquor which was available for fermentation by yeast. With lower alcohol content hopped beer could be made with less sugar. Therefore it was not as sweet and took less grain to make since grain is the source of material for fermentation. That implied lower production costs but also implied a lighter and thinner drink. It may be that consumers thought the taste of hopped beer was better. It is not possible to be sure about issues of taste in general and specifically about the taste for the new type of beer. The fact that the new drink could last longer without losing its quality or without spoiling may have been a greater consideration than taste. Certainly a taste for beer made with hops could be acquired. Preservation of foods was one of the greatest problems of pre-nineteenth century Europe. The addition of hops in the brewing process made for a significant change in beer. It now became one of the few foods that would, at least for a while, keep without becoming inedible.

⁵ FRANK A. KING, *Beer Has a History*, London: Hutchinson's Scientific and Technical Publications, 1947, 42.

Some consumers did consider the new beer a higher quality product. It even came to compete with wine, long the preferred drink of the well-to-do, with noblemen buying hopped beer for their households as a supplement to purchases of wine. Certainly by 1350 and probably even by 1300 beer was no longer just a drink for peasants or servants. The larger market — a result of the technical change of adding hops — generated an industry first in Bremen and then in Hamburg for the export of beer. The principal overseas market was the Low Countries which formed a logical outlet not only because of the long-term preparation but also because of the relatively higher average incomes of urban dwellers there as compared to much of the rest of northern Europe. Flanders but also Brabant and Holland then were faced with a hopped beer invasion.

The brewing industry because of exports became a critical if not central feature of the economic life of Hamburg. A 1376 survey of the town showed of the 1075 people with a trade 457 or 43% were brewers. Of those 457, 126 brewed exclusively for the Amsterdam market and 55 for Stavoren, a smaller port in Friesland just to the north of Amsterdam. The total output of all Hamburg brewers by the mid-fourteenth century was about 240,000 hectolitres per year. Amsterdam was the chief port of entry in the Low Countries for the new higher quality hopped beer. The early growth and development of the port of Amsterdam depended heavily on its role as the centre for the import of Hamburg beer. From Amsterdam the beer went south to urban markets, principally in Flanders, along the network of inland waterways.

III

The influx of large quantities of the new product, superior to the traditional one, served as the sharp shock to local producers and forced them to change the product they made. This third step in the process was made even more dramatic in the case of

Holland and to a lesser degree in England by the actions of government authorities. In Holland hopped beer brewing was illegal. The Count of Holland prohibited the production of the new type of drink because he was fearful of losing income from existing taxes which he and other authorities levied on *gruit*. His resistance to the change to a new and superior product has no other apparent explanation. The flood of German hopped beer led in 1321 to Count William III of Holland forbidding the import of Hamburg and eastern beer. Just two years later in 1323 William lifted the ban but set restrictions on imports. In the future, he insisted, all beer for Holland would have to pass through either Amsterdam or Medemblik. The latter quickly faded as a port of entry and by 1351 only Amsterdam was mentioned in the Count's renewal of the restrictions. The Count also insisted that all beer entering Holland pay a tax, one which proved to be rather lucrative for him and his successors.⁶ Presumably the Count rescinded the earlier 1321 order because of public pressure, that is because of the popularity of hopped beer, and because of loss of revenue to him from a decline in consumption of beer.

Another change made by the Count in 1321 was that he allowed the production of hopped beer in Holland. His goal, it would seem, was to create a domestic industry which would replace imports. He made his own interests clear by taxing hops and doing so in a way that would guarantee that his income from taxes on beer consumption would stay the same. Urban brewers in Holland did develop hopped beer production but obviously not fast enough to satisfy the Count and his need for tax income. By 1326 the town of Delft, which would become a major brewing centre in the following century, had regulations

⁶ G. DOORMAN, *De Middeleeuwse Browwerij en de Gruit*, The Hague: Martinus Nijhoff, 1953, 25. P.H.J. VAN DER LAAN, *Oorkondenboek van Amsterdam tot 1400*, Amsterdam: N. Israel, 1975, #16, #129, #522. H.J. SMIT, *De Opkomst van den Handel van Amsterdam, Onderzoekingen naar de economische ontwikkeling der stad tot 1441*, Amsterdam: A.H. Kruyt, 1914, 31-34, 37-40, 45-49, 89-92, 103, 115.

on producing beer in what was called the eastern style. The rules limited the production of hop or turf beer, as it was also called, to the winter which meant from 1 Oct. to 1 May. That remained true up to 1340 when the town dropped the restriction. The limitation suggests that Delft brewers had some difficulty in changing to the new technology. It is possible though that since it was difficult to store the older type of beer through the summer the town wanted to have a supply of the longer-lasting hopped beer on hand in the warmer months just in case the usual production of *gruut* beer for any reason decreased or stopped. It made sense then to produce the hopped beer in the winter and store it for later use.⁷

Local producers in Holland, it seems, had difficulty in replacing imports, at least immediately. The technical innovation entailed only the simple replacement of one additive with another at one isolated point in the making of beer. No special equipment was needed, nor were there changes in working habits or working relationships. Yet Dutch brewers were slow to adopt the new method. It is true that the chemistry of hops is such that incorrect quantities of the herb can yield a poor taste while not enhancing the preservation of the beer. The essential oils of hops give an antiseptic effect which can be boiled away if the beer is heated too long. On the other hand if it is not boiled long enough bitters from the hops remain giving a harsh taste.⁸ It may have taken brewers in towns in Holland some time before they found the exact combination of hops, grain, water and boiling time to produce a beer of the quality of Hamburg beer.

Just to the south in Flanders and Brabant the shock to the brewing industry also seems to have been a flood of imports. As

⁷ DICK E.H. DE BOER, *Graaf en Grafiek Sociale en economische ontwikkelingen in het middeleeuwse 'Noorbholland' tussen ±1345 en ±1415*, Leiden: NRP, 1978, 274. G. DOORMAN, *De Middeleeuwse Brouwerij en de Gruut*, The Hague: Martinus Nijhoff, 1953, 18-20, 50-51.

⁸ JEAN DE CLERCK, *A Textbook of Brewing*, Kathleen Barton-Wright, trans. 2 volumes. London: Chapman and Hall Ltd., 1957-1958, vol. I, 60, 302-304.

Dutch brewers mastered the new method they began to export the longer-lasting beer first to nearby markets. Holland shippers had carried beer from North German ports to Flanders before domestic production of hopped beer began so it was easy for them to replace the Hamburg product with locally-produced beer. As early as 1388 the town of Delft exported more than 14,000 hectolitres to Bruges alone. In Antwerp in Brabant in 1418-1419 local brewers produced only 25% of the beer drunk in the town. Of the remaining three-quarters 97% of the imports came from the town of Haarlem, a quantity of more than 15,000 hectolitres.⁹ In 1485 all Flemish ports imported beer at an annual rate of 19,600 hectolitres. At Lier in 1408 about 70% of beer consumed came from Holland but by 1474 it had gone down to 25% as local production replaced imports.¹⁰ The pattern in the southern Low Countries — gradual replacement of imports as local producers perfected the ability to make beer as good as that flooding in from other markets — was similar to that in Holland almost a century before. That pattern was also similar to what happened in England.

The traditional malt beverage in England was called ale and in the fifteenth and sixteenth centuries that meant beer made with no hops. English ale was good enough to be exported to Holland before the changeover to adding hops. It has been said, incorrectly, that it was the Dutch who brought hopped beer to England for the first time in 1400, to the port of Winchelsea.¹¹ In fact the export of hopped beer from Holland to England existed already around 1380 and went on into the first years of the fifteenth century. For example, the port of Great Yarmouth

⁹ HERMAN VAN DER WEE, *The Growth of the Antwerp Market and the European Economy in the Fifteenth and Sixteenth Centuries*, 3 volumes, The Hague: Martinus Nijhoff, 1963, vol. I, 228.

¹⁰ R. VAN UYTVEN, "Haarlemmer hop, Goudse kuit en Leuvense Peterman". *Arca Lovaniensis Artes atque historiae reserans documenta Jaarboek 4* (1975), 339, 341.

¹¹ L.F. SALZMAN, *English Industries of the Middle Ages*, New edition, enlarged and illustrated, 295.

alone in the twelve months starting on 1 May 1398 saw the import of 65 lasts of hopped beer, that is some 860 barrels or 1032 hectolitres. That was an average of some 80 hectolitres per month. Imports seem to have fallen off in the 1410s,¹² perhaps a first sign of the development of an ability to produce the good in England.

The first mention of hopped beer is in the London City Letter-books from 1391. There it is mentioned together with Estrichbeer or eastern beer, the latter being imported beer with hops. In England, as in Holland a century or more before, efforts were made to stop domestic production of the new kind of beer. Opposition seems to have come principally from established ale makers who saw the new product and its brewers as a threat to their livelihoods. In 1436 the sheriffs of London issued a writ saying all beer brewers should go on with their trade, that despite attempts by local individuals to prevent natives of Holland and Zeeland as well as others from making beer by saying that it was poisonous, that it was not fit to drink and that it caused drunkenness. The Brewers' Company had existed in London since the late twelfth century but it was not formally constituted until 1406 and not incorporated until 1437.¹³ The organization was meant to represent ale brewers and the sudden interest in the legal status of the organization may have been in reaction to the invasion of hopped beer from the Low Countries and the immigrant brewers from Holland who brought the new product with them. Beer brewers, unlike ale brewers, were not subject to any official inspection or control so King Henry VI in 1441 appointed two men, with no experience of the trade, as surveyors and correctors of beer brewers throughout the kingdom. The inspectors received from the crown the power to take

¹² NELLY J.M. KERLING, *Commercial Relations of Holland and Zeeland with England from the late 13th Century to the Close of the Middle Ages*, Leiden: E.J. Brill, 1954, 110-111, 114, 216-220.

¹³ London, Guildhall, Ms. 5425. FRANK KING, *Beer Has a History*, 38, 42, 46. L.F. SALZMAN, *English Industries of the Middle Ages*, New edition, enlarged and illustrated, 295.

a halfpenny on every barrel that they or their appointees passed as good. In 1461 the London 'mystery of berebruers', an informal group, was asked to elect two men to act as searchers to guarantee compliance with rules of good conduct so the group had obviously grown. In 1484 the ale brewers, again perhaps in reaction, got the City of London to say that none of them could use hops, herbs or other like things in making any ale and that they could only use liquor, malt and yeast. The goal was to improve the quality of ale and so it was probably defensive, that is to allow ale brewing to survive in the face of competition from higher quality beer. The regulations, however, reinforced and institutionalized the distinction between the brewers of true ale and the beer brewers. That clear distinction established in the reign of King Edward IV was to continue to the reign of Queen Mary I in the mid-sixteenth century. In 1493, probably in part as a reaction to the rules of ale brewers, beer brewers became a definite guild.¹⁴

Despite the success of beer brewers in the course of the fifteenth century there was a continued dislike of hops. At Norwich, for example, their use, along with that of *gawle* was prohibited in 1471. In 1519 Shrewsbury authorities outlawed the use of hops, calling it a wicked and pernicious weed. The actions may have been more than xenophobia or just resistance to novelty and rather a reflection of a desire to maintain the standard and quality of old English ale. Andrew Boorde in his *Compendyous or Dyetary of Health* published in 1545 said that ale was a natural drink for Englishmen while beer was a natural drink for Dutchmen and much used in England to the detriment of many English people because beer makes men fat and inflates the belly. That was his explanation for Dutchmen's fat faces and bellies. He claimed, too, that beer would kill those with colic.¹⁵

¹⁴ H.S. CORRAN, *A History of Brewing*, Newton Abbot: David and Charles, 1975, 46. FRANK KING, *Beer Has a History*, 55. L.F. SALZMAN, *English Industries of the Middle Ages*, New edition, enlarged and illustrated, 296-298.

¹⁵ H.S. CORRAN, *A History of Brewing*, 53-55. L.F. SALZMAN, *English Industries of the Middle Ages*, New edition, enlarged and illustrated, 285, 295, 297.

The antipathy for and fear of the new product did not disappear even after beer became well established as a popular drink.

In the case of England the import of the technology was embodied in the brewers who immigrated into the country. It is the only case, it appears, in northern Europe in the later Middle Ages where in the first instance it was not domestic brewers who imitated the new method but rather it was skilled and experienced practitioners from elsewhere who transferred the technology to new surroundings. Any beer brewer in England mentioned in the fifteenth century is said to have had a foreign name. A 1531 Act of Parliament said that alien brewers were exempt from penal statutes against foreigners practising their trade in England.¹⁶ In that case, as earlier, the government acted to protect beer brewers against actions by the defenders of the old technology.

IV

In each case in northern Europe it proved necessary to make adjustments in manufacturing and distribution in order to acclimatize the new technique to local conditions. Though there is no conclusive evidence, it appears that brewers in North German towns made hopped beer long before they started exporting the product to the Low Countries.¹⁷ That suggests a period of slow development followed by mastery of the novel technique. In Holland the great advances in beer production did not come until the end of the fourteenth century, that is some 70 to 80 years after the brewing of hopped beer became legal in the province. From about 1390 the industry enjoyed rapid growth.

¹⁶ L.F. SALZMAN, *English Industries of the Middle Ages*, New edition, enlarged and illustrated, 297. H.S. CORRAN, *A History of Brewing*, 54.

¹⁷ WOLF BING, "Hamburgs Bierbrauerei vom 14. bis zum 18. Jahrhundert", *Zeitschrift des Vereins für Hamburgischen Geschichte*, 14 (1909), 218-20, 242-43, 268-70. FRIEDRICH TECHEN, "Das Brauwerk in Wismar", *Hansisches Geschichtsblätter* 21 (1915), 294-95, 316-22, 324-27.

The large number of breweries indicates the scale of the industry in the fifteenth century. In the fourteenth century Haarlem already had about 50 breweries. By around 1400 Amersfoort in the nearby province of Utrecht had the more than impressive number of 350. Later in the century, around 1480 Gouda may have risen to approximately the same number. Before 1494 Delft had more than 200 breweries and by that date Gouda had 157 and Haarlem 112. Both towns have seen their number of breweries decrease in recent years.¹⁸ Those Dutch breweries in the fifteenth century supplied not only the domestic but also a number of foreign markets. For example, in the 1430s 55% of Haarlem production was sold outside the town. By the 1460s in the face of competition from a number of other towns that proportion was down to around 30% but at the end of the sixteenth century, in the 1590s, the share was back up to about 65% of output. For Gouda exports were even more important. Around 1500 only 1 in 10 barrels of beer brewed in the town was consumed there, putting exports at about 150,000 hectolitres per year on average.¹⁹

The shift to hopped beer was a gradual one. Evidence for that comes from the taxes levied on beer production by the towns. The old tax on *gruit*, the *gruitgeld*, gave way to *hoppgeld*. Many towns in Holland had procured *gruitrecht*, the right to tax the use of that combination of herbs, from the Count of Holland by farming the tax from him in the thirteenth and early fourteenth centuries. By mutual agreement the same thing happened in the fourteenth and fifteenth centuries with *hoppgeld*.

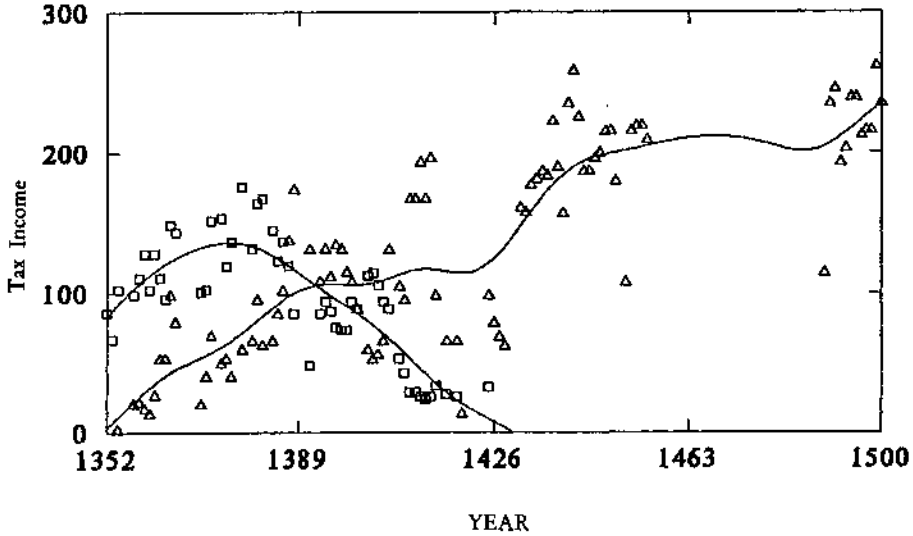
¹⁸ H. HALBERTSMA, *Zeven Eeuwen Amersfoort*, Amersfoort, n.d., 42. A. HALLEMA and J.A. EMMENS, *Het bier en zijn brouwers. De geschiedenis van onze oudste volksdrank*. Amsterdam: J.H. DeBussy, 1968, 65. JACQUES VAN LOENEN, *De Haarlemse Brouwindustrie voor 1600*, Amsterdam: Universiteitspers, 1950, 20.

¹⁹ JACQUES VAN LOENEN, *De Haarlemse Brouwindustrie voor 1600*, 55, 59, 64-65; A. HOUWEN, "De Haarlemsche Brouwerij 1575-1600", Unpublished Doctoraal scriptie, Universiteit van Amsterdam, 1932, 27. V.C.C.J. PINKSE, "Het Goudse Kuitbier: Gouda's Welveren in de Late Middeleeuwen 1400-1568", *Gouda Zeven Eeuwen Stad* (19 juli, 1972), 91.

The first excise tax on hops was levied at Delft in 1340 at a fixed fee per 10 vaten brewed. Similar town taxes emerged throughout the province over the next one hundred years. Data from those taxes show the slow pace of development of hopped beer brewing in the fourteenth century and the rapid development in the fifteenth. Tax figures exist for a number of Holland towns including those from Delft for the tax on *gruit* (1343-1408) and on hops (1343-1449), from Gouda on *gruit* (1356-1424) and on hops (1359-1598) and a second set from another tax on hops (1360-1584), from Leiden on *gruit* (1352-1425) and on hops (1354-1598). It would appear that these figures and especially those for Leiden are the most representative. There are also tax figures for both *gruit* and hops from the less important town of Schoonhoven and from Zutphen in the eastern part of the Netherlands. In addition there are records of taxes from Rotterdam on *gruit* (1352-1399), from Schiedam on hops (1352-1505) as well as from a Gouda tax on the sale of beer (1437-1553).²⁰ To deal with the many gaps in the data and to make the data comparable across towns and across time, in the cases where it was possible the average of tax income was taken for the period 1380-1409 and was used as a standard. Each surviving figure was divided by the average from the series for these 30 years and yielded an index of the tax income for the entire period covered by surviving data. The most reliable and representative of these figures are given in Table 1. Graphic representation of the data for Leiden and for Zutphen, below, illustrate the long term development in both *gruit* and hops taxes in the northern Netherlands and suggest the pattern of change in brewing.

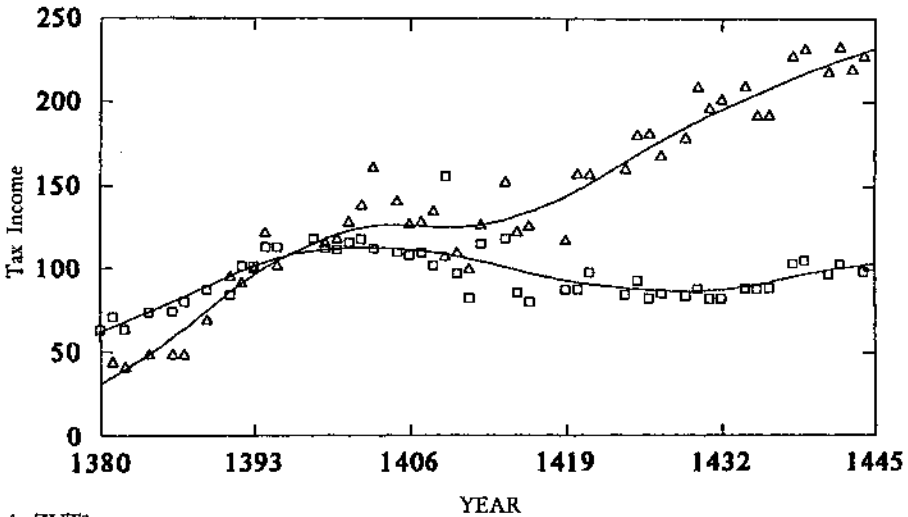
²⁰ Algemene Rijksarchief, The Hague, Archief van de Grafelijkheids-Rekenkamer of Rekenkamer der Domeinen van Holland, 197-424, 343-416, 1489-1499, 1696-1826, 5640-5673. Gemeente Archief Gouda, Aanteekeningen v.d. Poest Clement, Hopaccijn 1360-1584, *Bieraccijn* from Stadsrekeningen, 1125-1200. DICK E.H. DE BOER, *Graaf en Grafiek Sociale en economische ontwikkelingen in het middeleeuwse 'Noorholland' tussen ±1345 en ±1415* 273-294. R. WARTENA, *De Stadsrekeningen van Zutphen 1364-1455/6*, 3 volumes, Zutphen: Gemeente Archief, 1977.

Figure 1
INCOME FROM TAXES ON GRUIT (=LEIG)
AND HOPS (=LEIH) AT LEIDEN



△ LEIH
□ LEIG

INCOME FROM TAXES ON GRUIT (= ZUT2)
AND HOPS (=ZUT3) AT ZUTPHEN



△ ZUT3
□ ZUT2

Table I
 INCOME FROM TAXES ON GRUIT, HOPS AND BEER
 AVERAGE 1380-1409 = 100

Year	Delft		Gouda			Leiden	
	Gruit	Hops	Gruit	Hops	Hops excise	Gruit	Hops
1343	1948.56	34.30	—	—	—	—	—
1344	2303.48	66.22	—	—	—	—	—
1345	—	—	—	—	—	—	—
1346	1391.83	57.94	—	—	—	—	—
1347	—	—	—	—	—	—	—
1348	—	—	—	—	—	—	—
1349	—	—	—	—	—	—	—
1350	—	39.21	—	—	—	—	—
1351	—	110.37	—	—	—	—	—
1352	—	110.37	—	—	—	85.44	—
1353	—	60.74	—	—	—	66.72	—
1354	—	88.95	—	—	—	102.53	1.76
1355	27.84	93.27	—	—	—	—	—
1356	—	—	418.19	—	—	—	—
1357	—	96.57	357.73	—	—	98.93	19.62
1358	—	109.35	579.42	—	—	110.86	21.22
1359	—	33.11	385.44	44.28	—	127.91	16.39
1360	—	55.19	—	—	45.14	102.33	13.06
1361	—	55.19	146.14	47.22	—	127.91	26.12
1362	—	63.46	125.96	66.99	64.12	110.86	52.23
1363	—	60.15	113.36	53.92	68.29	95.51	52.23
1364	—	48.57	100.77	89.86	54.96	148.39	97.94
1365	24.36	55.19	158.71	80.06	91.61	143.26	78.35
1366	—	—	—	—	81.61	—	—
1367	—	—	183.90	99.01	—	—	—
1368	—	—	214.13	127.60	100.93	—	—
1369	—	—	232.02	163.22	130.08	—	—
1370	1531.01	12.69	176.72	55.55	166.39	100.64	19.59
1371	904.69	10.49	289.71	74.66	75.62	102.35	39.21
1372	974.28	16.56	251.92	37.58	76.12	151.79	69.05
1373	—	—	272.07	66.17	38.31	—	—
1374	278.37	25.39	377.88	74.83	67.46	153.49	49.00
1375	278.37	35.32	292.35	64.07	76.28	119.38	52.23
1376	278.37	28.70	335.48	95.58	56.30	136.46	39.18
1377	—	—	338.03	102.28	76.45	—	—
1378	278.37	62.39	—	—	—	175.77	58.96
1379	—	—	—	—	—	—	—
1380	278.37	81.14	116.16	107.51	—	131.58	65.29
1381	278.37	82.78	—	—	109.59	163.76	94.94
1382	278.37	70.64	131.12	105.90	—	167.14	62.03
1383	—	—	136.34	74.20	107.93	—	—
1384	278.37	64.02	221.69	89.86	75.62	144.97	65.29
1385	34.80	70.09	217.11	100.66	91.61	122.81	84.91
1386	288.80	95.50	96.01	82.36	—	136.44	101.21
1387	219.91	101.54	125.96	95.58	—	119.38	137.12
1388	27.84	109.82	—	—	97.44	85.27	173.06

Technical Change in the Brewing Industry in Germany, The Low Countries, and England

Year	Delft		Gouda			Leiden	
	Gruit	Hops	Gruit	Hops	Hops excise	Gruit	Hops
1389	—	—	151.30	102.79	—	—	—
1390	—	—	108.53	99.19	104.76	—	—
1391	22.27	101.61	73.06	92.66	101.10	47.77	130.59
1392	—	—	100.92	104.26	94.44	—	—
1393	16.70	90.53	60.86	77.14	106.26	85.29	107.77
1394	12.53	125.28	65.70	78.42	78.61	93.82	130.62
1395	10.44	126.45	70.74	85.46	79.95	86.98	111.00
1396	11.83	115.37	90.89	90.21	87.11	75.04	133.85
1397	12.53	129.17	65.58	96.74	91.94	73.34	130.59
1398	12.53	128.03	93.21	102.30	98.60	73.35	114.26
1399	12.53	136.41	—	—	139.07	93.80	107.73
1400	12.53	138.03	—	—	—	88.68	88.15
1401	—	—	—	—	—	—	—
1402	17.40	36.98	—	—	—	112.56	58.76
1403	17.40	—	—	—	—	114.27	52.27
1404	281.85	—	83.51	114.69	—	105.74	55.50
1405	139.88	20.50	68.04	118.22	93.60	93.80	65.29
1406	27.14	—	38.24	115.86	99.93	88.68	130.59
1407	—	—	35.65	128.12	103.93	—	—
1408	7.66	131.43	49.38	137.89	114.92	52.89	104.50
1409	—	144.67	—	—	123.58	42.64	94.68
1410	—	121.96	—	—	—	28.99	166.53
1411	—	133.55	—	—	—	28.99	166.53
1412	—	134.66	—	—	—	25.60	192.62
1413	—	33.68	—	—	—	23.94	166.56
1414	—	36.53	—	—	—	25.60	195.88
1415	—	28.75	—	—	—	33.26	97.94
1416	—	—	—	—	—	—	—
1417	—	27.59	—	—	—	27.46	15.29
1418	—	19.87	—	—	—	—	—
1419	—	78.04	—	—	—	25.58	65.29
1420	—	17.16	—	—	—	—	1.06
1421	—	—	—	—	—	—	—
1422	—	—	—	—	—	—	—
1423	—	—	—	—	—	—	—
1424	—	—	1889.78	—	—	—	—
1425	—	—	—	—	109.93	32.57	97.94
1426	—	36.42	—	—	—	—	78.35
1427	—	32.56	—	—	—	—	68.56
1428	—	44.70	—	—	—	—	61.70
1429	—	—	—	—	—	—	—
1430	—	106.51	—	—	—	—	—
1431	—	88.90	—	—	—	—	160.33
1432	—	82.81	—	—	—	—	157.19
1433	—	45.84	—	—	—	—	176.75
1434	—	21.62	—	—	—	—	180.86
1435	—	191.53	—	—	—	—	186.38
1436	—	190.43	—	—	—	—	182.89
1437	—	151.86	—	—	—	—	222.32
1438	—	137.44	—	—	—	—	189.48

Year	Delft		Gouda			Leiden	
	Gruit	Hops	Gruit	Hops	Hops excise	Gruit	Hops
1439	—	139.63	—	—	—	—	156.70
1440	—	149.04	—	—	—	—	235.06
1441	—	152.33	—	—	—	—	258.04
1442	—	145.20	—	—	—	—	225.39
1443	—	172.24	—	—	—	—	186.09
1444	—	188.76	—	—	—	—	186.48
1445	—	189.87	—	47.38	—	—	195.88
1446	—	192.13	—	49.50	48.30	—	199.28
1447	—	195.44	—	54.41	50.47	—	214.82
1448	—	187.08	—	57.18	55.46	—	215.47
1449	—	88.35	—	—	58.29	—	179.56
1450	—	—	—	—	—	—	—
1451	—	—	—	—	—	—	107.73
1452	—	—	—	—	—	—	215.47
1453	—	—	—	—	—	—	218.96
1454	—	—	—	—	—	—	218.96
1455	—	—	—	—	—	—	208.94
1456	—	—	—	—	—	—	—
1457	—	—	—	—	—	—	—
1458	—	—	—	—	—	—	—
1459	—	—	—	—	—	—	—
1460	—	—	—	—	—	—	—
1461	—	—	—	—	—	—	—
1462	—	—	—	—	—	—	—
1463	—	—	—	—	—	—	—
1464	—	—	—	—	—	—	—
1465	—	—	—	61.92	—	—	—
1466	—	—	—	385.90	66.46	—	—
1467	—	—	—	391.13	—	—	—
1468	—	—	—	130.54	393.40	—	—
1469	—	—	—	130.54	398.73	—	—
1470	—	—	—	176.94	399.40	—	—
1471	—	—	—	304.15	414.72	—	—
1472	—	—	—	382.49	364.76	—	—
1473	—	—	—	422.83	586.28	—	—
1474	—	—	—	441.29	433.04	—	—
1475	—	—	—	454.19	451.87	—	—
1476	—	—	—	441.78	453.03	—	—
1477	—	—	—	364.01	451.37	—	—
1478	—	—	—	456.66	373.08	—	—
1479	—	—	—	389.56	422.88	—	—
1480	—	—	—	285.60	397.07	—	—
1481	—	—	—	282.01	291.14	—	—
1482	—	—	—	288.82	287.48	—	—
1483	—	—	—	287.24	294.30	—	—
1484	—	—	—	215.19	293.80	—	—
1485	—	—	—	277.92	219.35	—	—
1486	—	—	904.80	292.08	283.31	—	—
1487	—	—	—	263.87	—	—	—
1488	—	—	—	143.94	—	—	—

Technical Change in the Brewing Industry in Germany, The Low Countries, and England

Year	Delft		Gouda			Leiden	
	Gruit	Hops	Gruit	Hops	Hops excise	Gruit	Hops
1489	—	—	—	232.16	—	—	114.39
1490	—	—	—	154.58	—	—	235.06
1491	—	—	—	142.49	140.57	—	245.31
1492	—	—	—	142.49	145.24	—	192.75
1493	—	—	—	242.75	247.34	—	202.54
1494	—	—	—	295.88	301.63	—	238.94
1495	—	237.30	—	221.71	84.28	—	238.91
1496	—	237.85	—	295.72	301.47	—	212.20
1497	—	249.44	—	185.45	301.47	—	215.47
1498	—	237.85	—	247.36	252.17	—	215.47
1499	—	249.44	—	206.84	252.17	—	261.17
1500	—	267.65	—	206.84	281.15	—	235.06

Among other things the data show clearly that *gruit* taxes disappeared in the course of the early fifteenth century. The income from the tax must have become so small as to make it simply not worth administering. On the other hand, hop tax income unquestionably rose, slowly in the fourteenth century, until the closing decades or decade and then sharply. The increases were sustained. Comparing the performance of hop taxes from one town to the other correlations were high, reinforcing the impression that behaviour was much the same in all the towns of Holland.²¹ On the other hand, the performance of *gruit* tax

²¹ There were exceptions to the high Pearson correlation coefficients (R) for hops tax income, most notably for hop tax income in Leiden and in Gouda (R=.01), suggesting that the towns which relied heavily on exports such as Delft and Gouda faced market conditions at times at variance with those for the larger industrial town, Leiden, to the north. Both hop tax income series yielded high correlation coefficients with income in other towns for their hops taxes.

INCOME FROM TAX ON HOPS
PEARSON CORRELATION MATRIX

	Delft	Gouda	Leiden	Schoonhoven	Schiedam
Delft	1.000				
Gouda	0.744	1.000			
Leiden	0.792	0.005	1.000		
Schoonhoven	0.602	0.420	0.423	1.000	
Schiedam	0.218	0.468	0.038	0.135	1.000

income did not yield correlations as high as with hops tax income. The size of *gruit* tax payments were small and getting smaller, so slight absolute changes were large percentage changes. The apparent wide fluctuations and variations from town to town may then be nothing more than a statistical artifact.²²

The *gruit* tax may have disappeared but beer made with *gruit* did not. The old technology remained in place for some time, perhaps to satisfy conservative demand or to satisfy poorer consumers who could not pay for the better quality but presumably more expensive hopped beer. In England, for example, in accounts of a noble house from as late as 1548, it is clear that ale

NUMBER OF OBSERVATIONS

	Delft	Gouda	Leiden	Schoonhoven	Schiedam
Delft	95				
Gouda	47	176			
Leiden	79	122	168		
Schoonhoven	21	30	21	30	
Schiedam	47	64	51	21	79

²² The Pearson correlation coefficient (R) for income from the tax on *gruit* were typically low though those for Rotterdam compared to Schoonhoven (R=.77), to Gouda (R=.59), and to Delft (R=.51) were much higher. The number of cases for these tests was typically small since, for many towns, the *gruit* tax disappeared in the first half of the fifteenth century.

INCOME FROM TAX ON GRUIT

PEARSON CORRELATION MATRIX

	Delft	Gouda	Leiden	Schoonhoven	Rotterdam
Delft	1.000				
Gouda	0.445	1.000			
Leiden	0.299	0.403	1.000		
Schoonhoven	-0.106	0.421	0.058	1.000	
Rotterdam	0.507	0.592	0.307	0.766	1.000

NUMBER OF OBSERVATIONS

	Delft	Gouda	Leiden	Schoonhoven	Rotterdam
Delft	35				
Gouda	24	79			
Leiden	31	31	52		
Schoonhoven	17	34	24	34	
Rotterdam	31	62	48	24	147

was only for the sick, the young, ladies and a few others who preferred the sweeter ale to the slightly bitter beer.²³ In 1577 William Harrison in his *Description of England* spoke contemptuously of the old ale, saying it was thick and fulsome, calling it a 'cold and sick man's drink' and saying it was only popular with a few consumers any more.²⁴ The experience of England in the sixteenth century was presumably the experience in Holland in the fifteenth.

Both series for the income from the hop tax at Gouda were highly correlated with data on hop tax income from other towns but not highly correlated with income from the beer tax levied in the town. The weak relationship was a result of the existence of a massive export market for Gouda beer. Only a small portion of the beer produced was consumed in the town and the data confirm that exports were important for Gouda. As for the town of Zutphen, the correlations are mixed and, indeed, Zutphen seems to fit in only partially with the pattern in Holland.²⁵

²³ F. G. EMMISON, *Tudor Food and Pastimes*, London: Ernest Benn Limited, 1964, 56.

²⁴ L.F. SALZMAN, *English Industries of the Middle Ages*, New edition, enlarged and illustrated 299.

²⁵ The Pearson correlation coefficient (R) for the income from the beer excise at Gouda, a tax on consumption, compared to the tax on hops, a tax on production, was .38. For Zutphen the relationship between the income from *gruit* tax there with the same tax in other towns showed negative correlations but the relationship for taxes on hops were not only positive but also strong.

INCOME FROM TAX ON GRUIT

PEARSON CORRELATION MATRIX

	Delft	Gouda	Leiden	Zutphen
Delft	1.000			
Gouda	0.445	1.000		
Leiden	0.299	0.403	1.000	
Zutphen	-0.893	-0.183	-0.441	1.000

NUMBER OF OBSERVATIONS

	Delft	Gouda	Leiden	Zutphen
Delft	35			
Gouda	24	79		
Leiden	31	31	52	
Zutphen	18	18	26	51

This may have been because the town was some distance away from thriving markets in Holland and Flanders. It may have been that the pace of technical change was slower in Zutphen.

In all cases, though, income from the tax on hops was highly correlated with town income. That was because income from taxes on beer was in all Low Countries towns by the end of the fifteenth century such a large share of the total receipts of urban treasuries. In Haarlem, the share in the mid-fifteenth century was about one-half and the sudden and sharp fall in beer production late in the same century was a major contributor to the bankruptcy of the town. It was equally true to the south where, for example, in Antwerp a little later, from 1530 to 1543, anywhere from 51% to 62% of total receipts came from beer taxes, in the years for which figures survive.²⁶

In the southern Low Countries, in Flanders and Brabant, production levels for hopped beer were slow to rise as had been the case in Holland. The flood from Holland pouring into the market from the late fourteenth century prevented, or, at the very least, deterred the adoption of the new technique of mak-

INCOME FROM TAX ON HOPS

PEARSON CORRELATION MATRIX

	Delft	Gouda	Leiden	Zutphen
Delft	1.000			
Gouda	0.744	1.000		
Leiden	0.792	0.005	1.000	
Zutphen	0.256	0.476	0.523	1.000

NUMBER OF OBSERVATIONS

	Delft	Gouda	Leiden	Zutphen
Delft	95			
Gouda	47	176		
Leiden	79	122	168	
Zutphen	36	14	38	47

²⁶ JACQUES VAN LOENEN, *De Haarlemse Brouwindustrie voor 1600*, 10-17. HUGO SOLY, "De Brouwerijenonderneming van Gilbert van Schoonbeke (1552-1562)", *Revue Belge de Philologie et d'Histoire*, XLVI (1968), 339-40.

ing beer. There was also a reluctance on the part of governments to allow hopped beer brewing. That resistance was greater the further south and east the town was from Holland. For example, the bishop of Utrecht was strongly opposed to dropping *gruit*, but even he, by the end of the fourteenth century, allowed the use of hops in making beer in his jurisdiction. He did insist that the tax paid either on the hops itself or on the beer, by volume, that was produced with hops be the same as what he had received before. The Archbishop of Cologne tried to suppress the use of hops, since he held *gruitrecht*. Not until 1500 did he finally agree to take a rent in lieu of his right to tax *gruit*.²⁷ The final rise in hopped beer production in the Duchy of Brabant dates from second decade of the fifteenth century, that is about forty to fifty years after Holland had gone through the same change. Leuven became the great centre of brewing in the southern Low Countries. It was located near grain supplies and upstream from sizeable urban markets such as the rapidly-expanding Brussels. The Leuven industry was so successful that in the sixteenth century grape growing was driven from the nearby countryside as farmers went over to growing grain to supply malt for the brewers. In 1378 Leuven brewers made 77 times as much *gruit* beer as hopped beer. By 1408 it was about 4.5 times as much. By 1422 the relationship had turned around and they produced 2.6 times as much hopped beer as *gruit* beer. The 1436 tax records report their making only hopped beer. Leuven production in 1372 was about 46,000 hectolitres and it hardly changed over the next century, reaching 47,400 in 1472. But by 1522 it had risen to 77,000 hectolitres. This was still well below the Gouda total which in the 1480s averaged 264,000 hectolitres or the Haarlem total which in 1514 was about 200,000 hectolitres.²⁸ At Leuven even with the expansion in production

²⁷ H.S. CORRAN, *A History of Brewing*, 43. G. DOORMAN, *De Middeleeuwse Brouwerij en de Gruit*, 18, 80.

²⁸ JACQUES VAN LOENEN, *De Haarlemse Brouwindustrie voor 1600*, 45. V.C.C.J. PINKSE, "Het Goudse Kuitbier: Gouda's Welvaren in de Late Middeleeuwen 1400-

the process of growth was slow. In 1524 production had fallen again and so was hardly more than it had been in the late fourteenth century. There, as elsewhere, the industry was subject to substantial fluctuations from year to year.

The slow geographical expansion of the industry in the southern Low Countries westward toward the coast may, in part, be explained by problems of supplies of good quality water. The Flemish industry was always small even after taking on producing hopped beer. At the great port town of Antwerp the rapid expansion in production did not come until the 1550s when an impressive engineering project brought water of high quality to a site in a newly-developed part of the city. Once in place a number of breweries thrived around the new source of water supply. Production of beer rose rapidly from about 105,000 hectolitres per year in the 1530s to an annual average of some 255,000 hectolitres per year from 1558 to 1563 and climbing to 450,000 hectolitres per year by the early 1580s. On the other hand growth at Bruges to the west in Flanders was much slower and the total was lower. There production rose from about 80,000 hectolitres in 1482 to 160,000 in 1580.²⁹

In England as in the Low Countries it took time for the hopped beer industry to develop, for brewers to make the switch and acclimatize themselves to the new process and the new process to them. In the counties of Kent and Sussex, the first to be exposed along with London, to the influx of hopped

1568", 114, 128. R. VAN UYTVEN, "Bestaansmiddelen", *Arca Lowvaniesis* 7, *Jaarboek* 1978, 154. R. VAN UYTVEN, *De drankcultuur in de Zuidelijke Nederlanden tot de XVIIIde eeuw. Drinken in het verleden. Tentoonstelling ingericht door het stadsbestuur van Leuven, 9 juni - 5 augustus, 1973*, Leuven: Stadsbestuur Leuven, 1973, 32-33.

²⁹ HUGO SOLY, *Urbanisme en Kapitalisme te Antwerpen in de 16de Eeuw De stedenbouwkundige en industriële ondernemingen van Gilbert van Schoonbeke*, Antwerp: Gemeentekrediet van België, Historische Uitgaven Pro Civitate, reeks in-8°, nr. 47, 1977, 294, 307, 312. HUGO SOLY and A.K.L. THYS, "Nijverheid in de Zuidelijke Nederlanden", *Algemene Geschiedenis der Nederlanden*, vol. VI, Haarlem: Fibula-van Dishoeck, 1979, 47. HUGO SOLY, "De Brouwerijenonderneming van Gilbert van Schoonbeke (1552-1562)", 347-349, 355-374, 1187, 1198.

beer from the Netherlands, the changeover to the new technique moved across the countryside from town to town to village. This march through east Sussex, at least so it seems, was complete by the end of the fifteenth century. In 1520 the town of Coventry, in the Midlands and some distance from those early sites of beer brewing, with a population of 6,600 had 60 public brewers making hopped beer.³⁰ It was not, perhaps, until the mid sixteenth century, however, that hopped beer dominated English brewing and beer consumption. The Brewers' Company in London got new charters from Queen Elizabeth I in 1560 and 1563. The two documents confirmed the previous charter of King Henry VI. The Company by that time included both ale and beer brewers with no distinction made any longer between the two groups.³¹ Presumably ale brewers by that time formed such a small portion of the total that there was no need for them to maintain a separate guild.

V

With acclimatization came, in each case, signs of brewers gaining full mastery of the new technology. The various figures on production suggests that such mastery was achieved from around 1300 in north Germany, around 1390 in Holland, around 1470 in the southern Netherlands and around 1550 in England. The level of hopped beer exports are often the best indicator of maturity in dealing with the dominant technology. The level of regulation, the degree of institutionalization and the refinement of ways of dealing with the new technique also serve as indicators of maturity, although less frequently. For Germany the evidence comes almost exclusively from the level of those exports. There was, though, increasing and careful regula-

³⁰ MAVIS MATE, "Urban Society", in *Sussex Society, 1400-1530*, in manuscript. L.F. SALZMAN, *English Industries of the Middle Ages*, New edition, enlarged and illustrated 290.

³¹ FRANK A. KING, *Beer Has a History*, 64. London, Guildhall Mss. 5427, 5428.

tion of exports. At Hamburg the goal was to maintain the quality of beer sent out of the port and so maintain a competitive position in foreign markets.³² Town governments showed a consistent interest in controlling the brewing industry both to retain economic strength but also to guarantee their critical tax income from the trade. By definition, though, towns were at the same time by that legislation forcing on brewers the use of the different technology. Governments and brewers must have been successful. Another sign of the maturity of the industry was the rise in consumption of beer, both in total and per person in northern Europe through the sixteenth century. At Hamburg around 1475 natives drank about 310 litres per person per year but by 1550 that figure was up to 400 litres and by around 1615 the number had risen to 700 litres, including all types of beer.³³

For Holland signs of a mature industry able to produce on large scale and fully in command of the technique of using hops appear in the first half of the fifteenth century. The principal indicator is again exports, in this case exports to Flanders and to England. Success appears as well in consumption data. At Haarlem in 1475 the average level was some 250 litres per person per year. By about 1590 that number was up to 300 litres. Other estimates of per capita consumption show increases over time and there may be a tendency to underestimate levels of beer drinking in sixteenth-century Holland.³⁴ Of course beer consumption was influenced by other factors than the ability of the

³² WOLF BING, *Hamburgs Bierbrauerei vom 14. bis zum 18. Jahrhundert*, 236-39, 244-45, 253-56. FRIEDRICH TECHEN, "Das Brauwerk in Wismar", 22 (1916), 176, 179, 200.

³³ HANS HUNTEMANN, *Das deutsche Braugewerbe vom Ausgang des Mittelalters bis zum Beginn der Industrialisierung. Biererzeugung - Bierhandel - Bierverbrauch*, Nürnberg: Verlag Hans Carl, 1971, 28, 59-60.

³⁴ JACQUES VAN LOENEN, *De Haarlemse Brouwindustrie voor 1600*, 52-59. He notes that his estimates may be subject to a downward bias because they are based on tax receipts and certain groups enjoyed tax freedom. As a result his figures should be taken as minima.

brewing industry to deal with problems of using hops for flavouring. For example, in the wake of large population losses in the second half of the fourteenth century market conditions changed, tending to yield higher real incomes for the usual beer consumers. This change could only help brewers. Similarly the greater level of urbanization in the sixteenth century, most notable in Holland, and the growth in shipping within Europe which lowered transport costs, contributed to the rise in consumption of beer per person. Those conditions prevailed throughout northern Europe but the timing of consumption growth was different, suggesting that mastery of hopped beer technology played a role in the rise in beer drinking.

In the southern Low Countries the rise in per capita consumption was equally a sign of the maturity of the industry. In both Antwerp in 1418 and in Leuven in 1434 per capita consumption was some 210 litres per year. In 1524 the figure for Leuven was about 275 litres per person per year. At Antwerp in the 1540s consumption was around 350 litres per person per year and by about 1628, much later, at Leuven the figure was up to 400 litres. Equally a sign of the growing strength of the industry was the investment made in developing sites for brewing at Antwerp and for bringing supplies of water to brewers in the 1550s. The scale of the project was massive by contemporary standards. It could only have been carried out under circumstances where, among other things, there was widespread confidence in the brewers' ability to produce hopped beer reliably and in large quantities, that is once they had proper supplies of water. One result of producing beer of better quality was the replacement of imports at Antwerp and the development of a thriving export of beer, especially to markets like nearby Zeeland where Dutch beer had dominated in the past. Imports at Antwerp fell from about 75,000 hectolitres per year in the first half of the sixteenth century to about 28,000 in the late 1550s. By the later date exports had risen from almost nothing at the

start of the century to an annual average of about 27,000 hectolitres.³⁵

In England the shift in both production and consumption from ale to hopped beer by the mid-sixteenth century suggests that brewers by then had command of the technique of making hopped beer. By that time there is also a number of references to exports of beer from England. For example a 1543 Act of Parliament prohibited the export of beer in anything larger than a barrel. Also every exporter of beer had to import an amount of wood equal to that which went out of the country as a beer barrel. Though the goal was to protect wood supplies in the kingdom the legislation suggests there was a sizeable export of beer. At the end of the century in 1591 26,400 barrels or almost 40,000 hectolitres of beer were exported from 20 great breweries on Thames-side in London. Fynes Morison in his *Itinerary*, published in 1617, said that English beer was by that time famous in the Netherlands and lower Germany.³⁶

VI

Once fully in command of the new technique it appears that brewers carried on both by design and by default a series of experiments leading to innovations in the process of making beer to exploit fully the opportunity created by the addition of hops to the brew. Trying to identify and isolate such a process innovation is even more elusive than trying to establish mastery of the new technique. The available evidence of the innovation is limited at best and often ambiguous. Certainly the pace of pro-

³⁵ HUGO SOLY, *Urbanisme en Kapitalisme te Antwerpen in de 16de Eeuw De stedeboouwkundige en industriële ondernemingen van Gilbert van Schoonbeke*, 291, 310-15. HUGO SOLY, "De Brouwerijenonderneming van Gilbert van Schoonbeke (1552-1562)", 349-351, 1185-87. R. VAN UYTVEN, *De drankcultuur in de Zuidelijke Nederlanden tot de XVIIIde eeuw. Drinken in het verleden*, 34.

³⁶ H.S. CORRAN, *A History of Brewing*, 65-66. FYNES MORYSON, *Itinerary*, London, 1617, in *Harrison's Description of England in Shakespeare's Youth*, Frederick J. Furnivall, ed., London: Chatto and Windus, 1908, 269.

cess innovation was slow. To get more from the earlier breakthrough, brewers tried a larger scale of production and even greater specialization in production than before. The most noticeable sign of the change was the growing size of the brew kettle. Since hopped beer lasted longer it made sense to produce it in larger quantities and so take advantage of economies from the larger scale. Savings from making more beer in each batch came in lower capital expenditures but also in lower labour costs per unit of output.

At Hamburg in the fifteenth and sixteenth centuries a brew was typically about 4,200 litres. By 1400 though the maximum size of a brew was up to 6125 litres. By 1540 the figure was up to 8750 litres, a sharp increase and much higher it appears than contemporary Dutch levels. A Nürnberg recipe of 1470 suggests a total of 6400 litres for one brew so the scale of brewing in Germany may have been in general larger than in the Low Countries.³⁷

For Holland the dates of process innovation are equally hard to establish but it appears brewers started as early as 1450 to improve production methods and that they continued to do that through the late sixteenth century. The decision to experiment may well have been forced on them by competition both internal from other Dutch brewers and external, from producers in traditional Dutch export markets. The rate of growth in production in Holland slowed in the late fifteenth century. The income from hop taxes tended to stabilize in money terms in late fifteenth and sixteenth century Gouda and less so in Leiden, suggesting a fall in real income from the tax to the towns as the general price level rose. Changes in the distribution of income at home which did not favour traditional beer drinkers and the development of alternate suppliers in export markets such as Flanders and England contributed to the slower pace of growth. To

³⁷ G. DOORMAN, *De Middeleeuwse Brouwerij en de Gruit*, 65. HANS HUNTEMANN, *Das deutsche Braugewerbe vom Ausgang des Mittelalters bis zum Beginn der Industrialisierung*, 10-12.

combat the problems brewers increased the size of their brew kettles. Smaller and less efficient producers resisted the advance. They called on the government to maintain an upper limit for the size of the kettle. The ruler of the county tended to favour larger kettles, siding with the larger producers in the political conflict which ensued. Though backing the more aggressive producers was an unpopular position the government still typically supported process innovation. At Delft there was a limit of 8,500 full tonnen that could be produced in a year by a single brewery. Some brewers set up two breweries to circumvent the regulations. They also lobbied the town government and got the number raised by 1566 to a maximum of 10,000 tonnen.³⁸

The figures from different towns throughout Holland for the maximum size of a brew show the trend toward a larger scale of production. At Delft in 1340 the brew was 37.3 hectolitres but that was large compared to Utrecht in 1404 at 31.0 or Haarlem in 1407 at 17.9 hectolitres. The variations were in part dictated by the type of beer but also dictated by the economics and technology of brewing. In 1484 at Amersfoort brew size varied from 27.6 up to 36 hectolitres. At Gouda in 1488 the figure was 38.2. Just a few years later through at Leiden in 1497 the brew varied from 43.5 to 51.2 hectolitres. At Haarlem in 1514 the maximum was 36.0 hectolitres but around 1550 the figure varied from 38.4 to 48 hectolitres and by 1594 it was 60.0 hectolitres. Though that level was a high one certainly the size of the single brew, which varied in the fifteenth century from 20 to 30 hectolitres and by 1500 had tended toward the higher figure, was in the high 40s at least by the late sixteenth century if not before.³⁹

³⁸ A. HALLEMA and J.A. EMMENS, *Het bier en zijn brouwers. De geschiedenis van onze oudste volksdrank*, 67.

³⁹ G. DOORMAN, *De Middeleeuwse Brouwerij en de Gruit*, 48, 65, 96-98. H. HALBERTSMA, *Zeven Eeuwen Amersfoort*, 42-44. H. HUNTEMANN, *Das deutsche Braugewerbe vom Ausgang des Mittelalters bis zum Beginn der Industrialisierung*, 74-75. JACQUES VAN LOENEN, *De Haarlemse Brouwindustrie voor 1600*, 45-47. V.C.C.J. PINKSE, "Het Goudse Kuitbier: Gouda's Welvaren in de Late Middeleeuwen 1400-1568", 100, 108. R. VAN UYTVEN, "Bestaansmiddelen", 154.

Larger individual brews, growing at a faster rate than consumption levels, led to a decrease in the number of breweries and an increase in the size of breweries. The size of the vat became more important through the sixteenth century as towns changed the tax structure. In addition to the hop tax towns typically came to levy a fixed charge for each time the brewer made beer. The assessment for each vat made a larger brewing vessel even more valuable. The tax on each brew was intended to be more equitable but did have the tendency to promote the use of ever larger brew kettles and so promoted process innovation.

As in Holland, in the southern Low Countries the size of the brew kettle rose at about the same time or a little later. At Leuven, the largest brewing centre, there were 72 brewers in 1477 but the figure was down to 62 in about 1520 to 46 in 1565 and to 34 by 1597. In the half century after 1477 production almost trebled while the number of brewers fell by almost 15% so each of the surviving brewers was making on average something approaching four times as much beer each year. From 1526 to 1565 production rose by another 50% while the number of brewers fell by 25%. In addition to the growing size of the kettle, the frequency of brewing increased to get more out of the increased capital investment in vessels for brewing and fermenting. At Amersfoort in 1574, for example, brewing more than once a week was finally allowed. At Leuven brewers in 1455 brewed an average of 56 times each year, in 1465 about the same, in 1483 63 times, in 1526 50, but by the end of the century in 1598 it was 98 times each year.⁴⁰ The greater intensity was an indication of the greater and fuller exploitation of the technical change begun in the early fifteenth century.

In England the process of refinement in technique is not as well documented. In 1585 the output of beer in London

⁴⁰ H. HALBERTSMA, *Zeven Eeuwen Amersfoort*, 43. R. VAN UYTVEN, "Bestaansmiddelen", 156-157. R. VAN UYTVEN, *Stadsfinancien en Stadseconomie te Leuven van de XIIe tot het einde der XVIe Eeuw*, Brussels: Paleis der Academien, 1961, 326-335.

amounted to 648,690 barrels of beer per annum produced in 26 breweries.⁴¹ At 120 litres for each barrel the total was about 850,000 hectolitres. There appears to have been no difficulty over the size of each brew though at more than 32,000 hectolitres production on average per brewery. The scale of firms was large though by no means massive, that is in comparison to contemporary operations in the Low Countries.

VII

The development of the brewing industry set a pattern for later development. Like pottery making before it, it was a domestic chore that was taken over by specialists who then produced for a wide and growing market. Brewing became a commercial proposition. It was the first domestic chore, once commercialized, that was subject to technical advance and, in its wake, further development which served to make the industrial producer superior to the domestic producer, even to the extent of making the goods they produced differ from other goods. Brewing became modern in that success came from adaptation to technical advance, from exploiting opportunities created by innovations in the product. Success was based on borrowing from others, on imitating practice elsewhere and then improving the practice, even if slowly, once the new technology was adopted. Brewing also became modern in that success, both technical and economic, was based on being part of a network of trading, of exchange of goods and information. That was most obvious in the case of Dutch brewing but in fact it was just as true for England and for Brabant and probably Germany as well.

Brewing was not modern, however, in the ways in which technology was developed and improved. Innovation was ex-

⁴¹ H. STOPES, *Malt and Malting. An Historical, Scientific, and Practical Treatise, showing, as clearly as existing knowledge permits, what Malt is, and how to Make It...* London: F.W. Lyon, 1885, 10.

tremely slow by almost any measure. Advances came if at all through painstaking trial-and-error, often it would appear with significant losses to brewers because of mistakes they did not understand. There was still in the sixteenth century a belief in the importance of magical powers in the making of good beer. Such beliefs may have served to slow technical innovation. Brewing, however, was both medieval and modern in the importance of government regulation to the development of the industry, both economically and technologically. Governments took an active interest in the industry and an even greater interest the more successful were the brewers.

The history of brewing in northern Europe at the end of the Middle Ages and through the sixteenth century shows more than just features common to the period before and common to the period after. It suggests a pattern of technical change, one which certainly was not always followed everywhere or for every productive process, but one which at least showed some consistency from one part of the continent to the other. This pattern at least suggests the way in which technical advance took place, the forces which influenced the pace and direction of the adoption and adaptation of new methods, and how some technical change could lead, over the long term, to extensive changes in the economy.

