Markets and Economic Growth: The Grain Market of Medieval England[1]

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England from 1200 to 1600 was a society caught in apparent technological stasis. Many have believed that this was the result of political and cultural constraints on the operation of markets. Here I show using information of grain yields and prices at 227 different locations that the most important of all markets, that for grain, was both extensive and relatively efficient. Whatever the rhetoric of medieval society the real effect of constraints on the operation the grain market seem to have been minimal. England had an elaborate market economy at least 500 years before it had sustained economic growth.

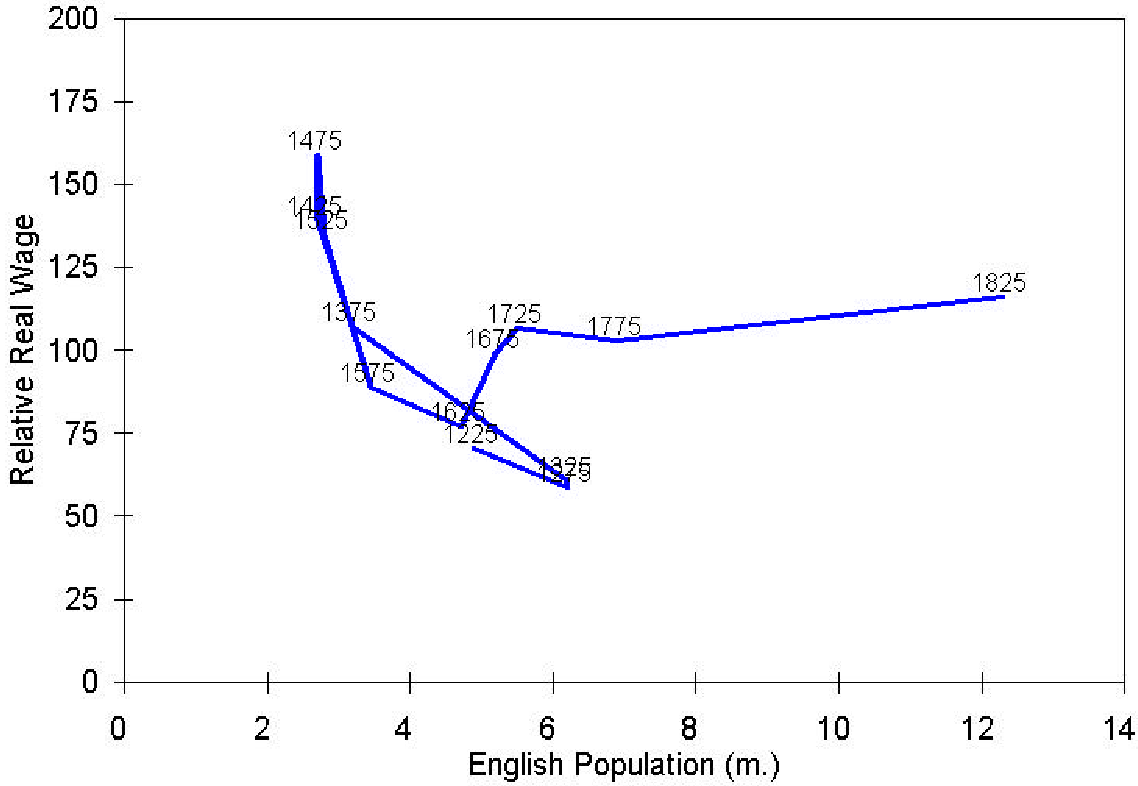
1. Introduction

The long technological stasis of pre-industrial England can be illustrated easily in a simple diagram. Figure 1 shows farm real wages, by half century, against the population of England. The observations from 1200-49 to 1600-49 lie along the same line, suggesting no improvement in the productivity of the economy in this long interval. Only around 1650 is there any sign that the productivity of the economy had advanced beyond that of 1200.

Yet we will see below that as early as 1208 the English grain market was both **extensive** and **efficient**. The market was extensive in that transport and transactions costs were low

[1]This paper draws heavily on the work of four great compilers of medieval data - James Thorold Rogers, Lord Beveridge, Jan Titow, and David Farmer - without whom we would be a lot poorer. I thank Bob Allen, Peter Lindert, Deirdre McCloskey, Joel Mokyr, Alan Olmstead, Debra Swenson, Alan Taylor, and Leon Wegge for helpful suggestions. Matt Rafferty and Brian Harris provided able research assistance. Cheryl Avery, of the University of Saskatchewan Library Archives, was extremely helpful when I visited Saskatchewan to study the papers of the late David Farmer.

Figure 1: Real Agricultural Day Wages and Population, England, 1200-1849



Notes: The observation for 1250-1299 lies in the same place as that of 1300-49 since both population and real wages are estimated to be approximately the same in these periods.

Sources: Clark (1999).

enough that grain flowed freely throughout the economy from areas of plenty to those of scarcity. Thus the medieval agrarian economy offered plenty of scope for local specialization. The market was efficient in the sense that profit opportunities seem to have been largely exhausted. Grain was stored efficiently within the year. There was no feasting after the harvest followed by dearth in the later months of the year. Large amounts of grain was also stored between years in response to low prices to exploit profit opportunities from anticipated price increases. There seems to have been less storage from year to year, and greater price rises within the year in the period before 1350 than in later periods. But this probably owes more to the high rates of return on capital in the early economy, rather than to any failure of traders to exploit potential profits. There is indeed little evidence of any institutional evolution in the grain market between 1208 and the Industrial Revolution.

That the agrarian economy could have been thoroughly organized by market forces at least 500 years before the Industrial Revolution is of some consequence for our thinking on the institutional prerequisites for modern economic growth. Many economists and historians have wanted to stress the development of markets and of the institutions which support markets as a vital break between the relatively static world of the pre-industrial economy, and the dynamic world of the Industrial Revolution. The market supposedly works its magic for economic growth by allowing specialization and hence increasing returns to scale. In the pre-market world each family produces what it consumes, inhabiting an island economy, where self sufficiency is purchased at the cost of inefficiency. Only when institutions evolve which encourage trade can production be specialized by region and by worker, and can economic growth begin.[2]

[2] Thus Douglass North in his Nobel Prize lecture noted that "Most societies throughout history got "stuck" in an institutional matrix that did not evolve into the impersonal exchange essential to capturing the productivity gains

If the medieval grain market was to all extents functional it implies that growth through the extension of markets - Smithian growth - was in the end a limited and modest source of growth. The perfection of a market economy by 1200 or earlier was followed by 500 years of near stasis in the English economy. The miracle of the Industrial Revolution must have had a very different source.

2. The Case for Imperfect Medieval Markets

Markets in the medieval England were traditionally regarded as limited, and poorly functioning for a variety of reasons. First the average level of grain prices reported across southern England in a relatively small geographic area varied widely by location. Figure 2 shows, for example, for an area of southern England around London of about 150 miles by 100 miles the average wheat price at specific locations as a percentage deviation from the national average. The national price was calculated from prices in a set of 227 manors for the years 1208 to 1500 which yielded prices in at least two different years using the regression

$$\ln(P_{it}) = \sum_i a_i + \sum_t b_t D_t + e_{it} \qquad (1)$$

where P_{it} is the average price level at manor i in year t, the α_i are intercept terms for each location i, and D_t are indicator variables which are 1 for each year t in turn, 0 otherwise. As can be seen some manors exhibit substantial deviations from the average price level, and these deviations are statistically and quantitatively very significant. Average prices for wheat were about 6 shillings per quarter, and overland transport costs for wheat circa 1300 were about 0.2

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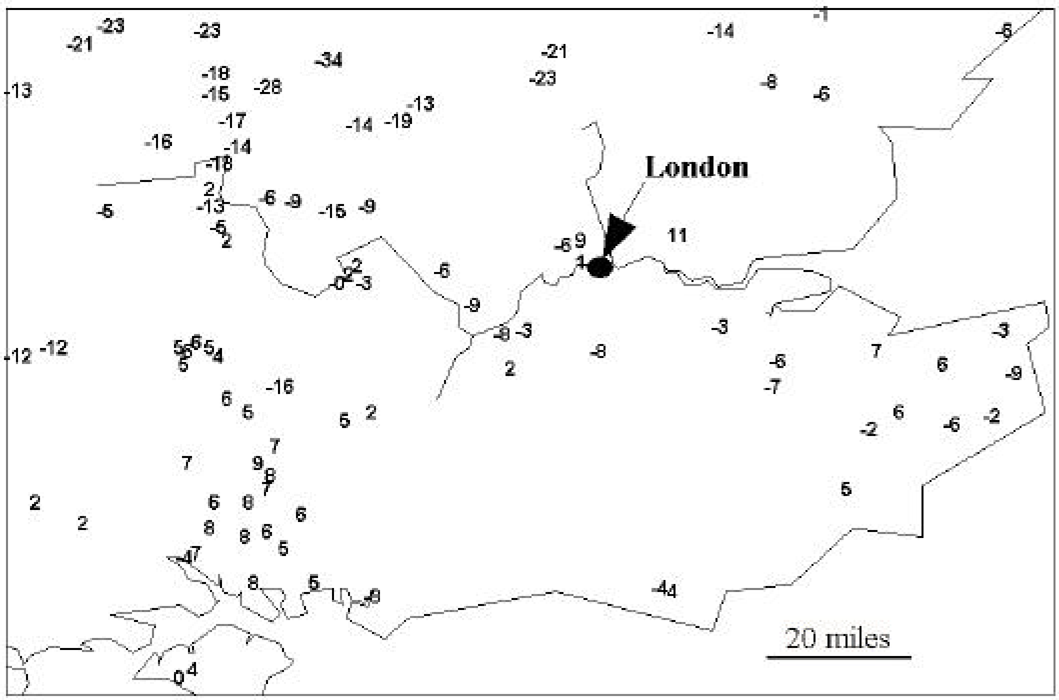
that came from the specialization and division of labor that have produced the Wealth of Nations." North (1994), p. 364.

shillings per quarter per 10 miles. Thus in an efficient market no places less than 30 miles apart

Figure 2: Average Wheat Price Levels in South East England on 93 Manors, 1208-1499



Notes: Prices in each location are shown as the average percentage deviation from the national average price. To show all the observations some of the manors are displaced slightly in the figure. The Rivers Thames, Lea, and Wey are also shown, though they are not believed to have been navigable over the whole length portrayed in this figure in the medieval period. See Campbell, Galloway, Keene and Murphy. (1993), pp. 193-8.

Sources: The wheat prices are from Rogers (1866, 1882), Beveridge Papers, Boxes G2, P2, Farmer Papers, files III/C/5, III/B/50.

should show average price differences of more than 10%.[3] Since many places in figure 1 violate this rule it has been argued that markets in the medieval period were local in character, or that recorded transaction prices do not reflect economic values.

Further McCloskey and Nash (1983) argue that there was little storage of wheat from year to year and within the year, leading to large year to year fluctuations in grain prices, and high prices just before the harvest. Within each year there was feast after the harvest and famine just before the next harvest. The surplus produced in good harvest years was consumed immediately with little effect on future prices.

The poor functioning of medieval markets has been attributed to a number of sources. Historians believed that medieval societies had a different mentality from ours, and was suspicious of, or even hostile to, the activities of intermediation so vital to the functioning of markets. As Bridbury notes in his essay "Markets and Freedom in the Middle Ages"

> Obviously it was not an environment in which markets themselves could function freely. A thousand obstacles, many formidable, others tenuous, impeded their activities at every turn.[4]

The impediments to the free functioning of the medieval market were supposedly threefold. First there was the popular disapproval of what we would regard as perfectly legitimate mercantile activities. In the pre-industrial world *forestalling*, *regrating* and *engrossing* were equally disapproved. To *forestall* was to buy up goods in anticipation of a rise in prices, to *regrate* was to buy up goods cheaply with the hope of retailing them at a profit, and to *engross* was to monopolize a market. Yet *forestalling* and *regrating* are both essential to the smooth

[3] Campbell, Galloway, Keene and Murphy. (1993), pp. 193-8 give transport costs. Water transport costs were even lower, being only about one tenth of land transport costs.

[4] Bridbury (1992), p. 264.

operation of markets. Thus in medieval London there was a full panoply of market regulations and traders were being charged in court with forestalling, or with selling at too high a price.[5] Similarly in Bristol in the fourteenth century it was illegal to store up grain from one market to another to sell it at a higher price.[6] Second given the importance of grains in the diet of the poorest the authorities tended to intervene in times of high prices to try and reduce price levels, by forcing sales at lower prices or confiscating grain. Finally the crown had a traditional right of "purveyance", which enabled it to buy grain below the market price. The accounts of 1321-2 for the Westminster Abbey of Bourton on the Hill in Gloucester, for example, record sales of oats at 4/- per quarter "sold for fear of the King's Ministers," and a sale at 2/8 per quarter "to the King's Ministers".[7]

3. The Spatial Functioning of the Grain Market

I test for the extent and efficiency of the medieval grain trade first by looking at spatial functioning of the market. Persistent price differentials between places that are greater than the transport costs between them would imply inefficiency. But there is great uncertainty for the medieval period about the size of local bushel measures used to measure grain, and grain quality may have varied by location. Indeed there has been a long debate about what measure was used on the Winchester estates which are the source for about half the price observations.[8] Even if

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[5] Campbell, Galloway, Keene and Murphy (1993) gives a nice description of the operation of the market. See pp. 87-106.

[6] Gras(1915), p. 72.

[7] There is a similar notation in 1347-8. Beveridge MSS., Box P3. Thorold Rogers annotates some of his grain sale listings with "king", but such annotations are rare, and the reported prices are not much less than others of the same year. See, for example, Rogers (1866), p. 98, Cuxham, 1331-2.

[8] See Beveridge (1930), Farmer (1957), Farmer (1991), pp. 499-501.

large price differentials were explained by transport costs, it would imply a market of limited extent where local conditions were important in determining local prices.

The uncertainty about measure, grain quality, and transport costs suggests a better test of the spatial efficiency of markets is to look at what determined local prices. If markets functioned efficiently, and transport costs were low, the grain yield in a village should have had little effect on the price level. If yields were low there, but higher elsewhere, grain would flow in and keep prices low. If yields were high, but low elsewhere, then grain would flow out driving up prices here also. If, however, each village was isolated from the market then the only determinant of local prices would be local yields. What happens elsewhere in the economy would have no impact locally. Since yields varied considerably from place to place in any given year this should be a powerful test of the integration of the market. Thus the correlation of wheat yields between Fareham in Hampshire and Taunton in Somerset, 85 miles away, averaged –0.13 over the years 1211-1349.

For 65 of the 227 manors for which we have wheat price information we also have sufficient data wheat yields and prices to carry out the test suggested above. To test the prevalence of markets formally I estimate the coefficients in two regressions. The first is

$$ln\, P_{jt} \quad = \quad a_0 \quad + \quad b_0 ln(Y_{jt}) \quad + \quad e_{jt} \qquad (2)$$

where P_{jt} is the average price in a given manor j in the year beginning in September 29 of year t, and Y_{jt} is the local yield in the harvest of the autumn of that year. e_{jt} is a random element which enters because of errors in the measurement of prices, and the fact that prices vary over the course of the year. The grain whose prices are represented in P_{jt} is thus principally the grain harvested just before the beginning of that account year. Because of the problems of non-standardized measures of acres, the yield is given as a multiple of the amount of seed sown. This first regression is used to check whether the yield figures are meaningful. If they are there should be a negative correlation between yields and prices locally whether or not the market is spatially integrated. Local yields will correlate with local prices even in a perfectly integrated market since local yields will correlate to some degree with national yields.

The second regression I estimate is

$$lnP_{jt} = a_1 + b_1 ln(Y_{jt}) + c\, lnP_t^* + d lnDECP^*_t + e_{jt} \qquad (3)$$

where P^* is the general wheat price in England estimated from equation (1), and $DECP^*$ is the average of that price for each decade. $DECP^*$ is put in so that long term movements in the general price level do not cause a spurious association between P_{jt} and P_t^*. The predictions we would get for the estimated coefficients in this second regression are:

	b_1	c
local markets	<0	0
complete national market	0	1

With no market operating outside prices will have no effect on local yields once we control for these, and prices will drop when yields are high (so that b_1 will be negative). With a complete market operating local yields will have no effect on prices so that b_1 will be 0, and local prices will move in line with outside prices so that c will be 1. In the intermediate case where transport and transaction costs are high enough to blunt the influence of national market conditions on local conditions both b_1 and c will be significantly different from 0.

Table 1 shows the estimated values of b_0, b_1 and c using data for 54 Winchester manors, 9 Westminster manors, one Merton manor and one Ely manor from 1211 to 1452. As can be

Table 1: The Determinants of Local Prices, 1211-1453

Manor	County	N	EQUATION 2		EQUATION 3			
			local yield	s.e.	local yield	s.e.	national price	s.e.
Winchester (54)		**4,699**	**-0.409****	**0.015**	**-0.027****	**0.006**	**0.990**	**0.007**
Adderbury	Oxford	101	-0.465**	0.117	-0.072	0.060	1.108	0.061
Alresford	Hampshire	120	-0.144	0.089	0.011	0.021	0.976	0.021
Beauworth	Hampshire	109	-0.321**	0.101	-0.011	0.033	0.978	0.031
Bentley	Hampshire	112	-0.459**	0.108	-0.010	0.041	0.921*	0.033
Bishops Waltham	Hampshire	125	-0.467**	0.102	-0.021	0.038	0.952	0.031
Brightwell	Oxford	122	-0.383**	0.127	-0.067	0.039	1.028	0.029
Burghclere	Hampshire	117	-0.644**	0.076	-0.022	0.030	0.974	0.030
Cheriton	Hampshire	113	0.027	0.088	0.021	0.025	0.946*	0.027
Crawley	Hampshire	120	-0.377**	0.095	0.011	0.029	1.006	0.028
Downton	Wiltshire	119	-0.158	0.107	0.006	0.032	1.027	0.029
E. Meon	Hampshire	125	-0.438**	0.096	-0.010	0.029	1.007	0.026
E. Meon Church	Hampshire	102	-0.428**	0.097	-0.060	0.031	0.959	0.029
Ecchinswell	Hampshire	116	-0.551**	0.095	-0.031	0.034	0.967	0.030
Fareham	Hampshire	121	-0.026	0.103	0.034	0.027	0.971	0.024
Farnham	Surrey	107	-0.457**	0.097	-0.039	0.040	0.920*	0.036
Fonthill	Wiltshire	106	-0.276**	0.091	-0.041	0.026	1.045	0.030
Hambledon	Hampshire	118	-0.217	0.120	0.009	0.061	0.868**	0.046
Harwell	Berkshire	115	-0.382**	0.101	-0.094**	0.032	1.041	0.031
High Clere	Hampshire	101	-0.482**	0.127	-0.015	0.044	1.001	0.034
Ivinghoe	Buckingham	110	-0.513**	0.086	-0.057	0.044	1.005	0.048
Knoyle	Wiltshire	104	-0.464**	0.110	-0.033	0.035	1.038	0.032
Mardon	Hampshire	116	-0.603**	0.106	-0.026	0.035	0.964	0.028
North Waltham	Hampshire	121	-0.351**	0.092	0.138**	0.036	1.057	0.036
Overton	Hampshire	128	-0.394**	0.091	0.012	0.028	0.995	0.026
Rimpton	Somerset	106	-0.551**	0.078	-0.103**	0.040	1.033	0.048
Sutton	Hampshire	115	-0.144	0.104	0.011	0.031	1.006	0.029
West Wycombe	Buckingham	108	-0.421**	0.095	-0.021	0.037	1.089*	0.040
Witney	Oxford	102	-0.661**	0.136	-0.126*	0.055	1.087*	0.044
Woodhay	Hampshire	101	-0.715**	0.111	-0.016	0.075	0.977	0.063
Westminster (9)		**245**	**-0.367****	**0.079**	**0.003**	**0.043**	**1.160****	**0.049**
Ashford	Middlesex	18	-0.270	0.236	0.199	0.149	1.330	0.214
Birdbrook	Essex	47	-0.459*	0.208	-0.033	0.134	1.019	0.114
Bourton	Gloucester	47	-0.371	0.240	0.111	0.114	1.328**	0.100
Eyebury	Middlesex	29	0.123	0.134	0.081	0.092	0.714	0.217
Feering	Essex	45	-0.582**	0.179	-0.110	0.091	1.030	0.082
Islip	Oxford	10	-1.205	0.680	0.544	0.259	1.468**	0.149
Stevenage	Hertford	11	-0.780*	0.382	-0.216	0.181	1.014	0.154
Todenham	Gloucester	35	-0.443**	0.156	-0.079	0.078	1.168	0.103
Cuxham (Merton)	Oxford	38	-0.415*	0.189	0.002	0.052	0.969	0.052
Downham (Ely)	Cambridge	9	-0.803	0.669	0.423	0.490	0.943	0.271
All (65 manors)		**4,991**	**-0.407****	**0.015**	**-0.025****	**0.006**	**0.997**	**0.007**

Notes: For yield as the dependent variable * = significantly different from 0 at the 5% level, ** = significantly different from 0 at the 1% level. For price as the dependent variable * = significantly different from 1 at the 5% level, ** = significantly different from 1 at the 1% level.

Table 2: The Determinants of Local Prices, 1211-1299

Manor	County	N	EQUATION 2		EQUATION 3			
			local yield	s.e.	local yield	s.e.	national price	s.e.
Winchester (39)		**1,113**	**-0.251****	**0.035**	**0.014**	**0.013**	**1.009**	**0.015**
Adderbury	Oxford	27	-0.452	0.325	-0.040	0.179	0.995	0.123
Alresford	Hampshire	34	-0.074	0.197	-0.025	0.048	1.018	0.046
Beauworth	Hampshire	27	-0.326	0.287	-0.024	0.088	1.034	0.064
Bentley	Hampshire	28	0.052	0.296	-0.057	0.101	1.015	0.072
Bishops Waltham	Hampshire	34	-0.243	0.190	0.093	0.073	0.978	0.067
Brightwell	Oxford	32	-0.790**	0.232	-0.171	0.095	0.955	0.068
Burghclere	Hampshire	29	-0.684**	0.209	-0.025	0.073	1.090	0.065
Cheriton	Hampshire	31	-0.145	0.204	-0.001	0.056	1.005	0.053
Crawley	Hampshire	35	-0.157	0.212	0.108	0.079	1.045	0.070
Downton	Wiltshire	38	-0.203	0.178	0.036	0.066	1.016	0.067
E. Meon	Hampshire	34	-0.127	0.179	-0.019	0.055	1.064	0.060
E. Meon Church	Hampshire	21	-0.203	0.194	-0.027	0.075	0.977	0.091
Ecchinswell	Hampshire	31	-0.554**	0.202	0.060	0.057	1.109*	0.052
Fareham	Hampshire	35	-0.000	0.288	0.048	0.084	0.937	0.050
Farnham	Surrey	28	-0.290	0.250	0.081	0.083	1.003	0.086
Fonthill	Wiltshire	25	-0.014	0.206	0.042	0.058	1.063	0.065
Hambledon	Hampshire	30	0.099	0.199	0.043	0.069	0.976	0.068
Harwell	Berkshire	28	-0.640**	0.189	-0.123	0.068	0.961	0.062
High Clere	Hampshire	23	-0.551*	0.273	-0.169	0.179	0.931	0.155
Ivinghoe	Buckingham	31	-0.506**	0.157	-0.121	0.078	0.987	0.091
Knoyle	Wiltshire	32	0.027	0.200	-0.034	0.079	0.981	0.077
Mardon	Hampshire	31	-0.282	0.272	0.066	0.065	0.983	0.043
North Waltham	Hampshire	33	-0.425*	0.210	-0.041	0.056	0.993	0.046
Overton	Hampshire	34	-0.007	0.167	0.034	0.039	1.044	0.044
Rimpton	Somerset	27	-0.092	0.215	0.120	0.105	1.121	0.122
Sutton	Hampshire	33	0.005	0.186	0.112	0.060	0.991	0.060
West Wycombe	Buckingham	32	-0.571**	0.188	0.169	0.089	1.080	0.080
Witney	Oxford	33	-0.691**	0.249	-0.071	0.120	1.036	0.089
Woodhay	Hampshire	22	-0.920**	0.278	-0.067	0.101	1.056	0.073
Westminster (6)		**51**	**-0.379***	**0.158**	**0.122**	**0.092**	**1.277***	**0.148**
Ashford	Middlesex	6	-0.267	0.423	0.355	0.759	2.108	2.104
Bourton	Gloucester	8	-0.990*	0.502	0.052	0.135	1.660	0.140
Eyebury	Middlesex	6	0.106	0.263	0.410	0.234	1.073	0.491
Feering	Essex	14	0.053	0.320	0.035	0.144	1.051	0.152
Todenham	Gloucester	13	-0.762**	0.283	0.121	0.177	1.489*	0.214
All (46 manors)		**1,167**	**-0.258****	**0.034**	**0.015**	**0.013**	**1.017**	**0.015**

Notes: For yield as the dependent variable * = significantly different from 0 at the 5% level, ** = significantly different from 0 at the 1% level. For price as the dependent variable * = significantly different from 1 at the 5% level, ** = significantly different from 1 at the 1% level.

seen if equation (2) is estimated, where only local yields are included, the yields almost always are connected as we would expect with local prices. That is, high yields are associated with low prices. When we introduce into the regression, however, the general wheat price level the effects of local yields generally disappears completely. In only 4 of the 40 manors in table 1 is the yield coefficient still statistically significant at the 5% level in the negative direction, while we would expect by chance 2 cases out of the 40 to show such significant deviations from 0. Our best estimate is thus that the pure effect of local yields on local wheat prices is that if yields double, prices would increase by about 2.5%. In contrast on average a 1% rise in the general price level is associated with a .997% rise in local prices, with a standard error of 0.007. This suggests that the market was working very well spatially, and that all the 65 manors observed were trading wheat in what was effectively a national grain market.

I can carry out exactly the same tests using just the data before 1300 to check if there was any sign that within the period 1208-1452 there was any change in the extent of the market. The estimates for 1208-1299 are given in table 2, and are the same as those for the whole period. Thus there is no sign that the market for wheat was becoming more integrated spatially over time within the medieval period.

What then accounts for the differences in the measured levels of prices at localities? Was it transport costs or was it just differences in local grain measures or grain quality? The extraordinary degree to which local prices were independent of local yields seems to imply that transport costs had to be low. Otherwise local conditions as revealed by local yields should help determine local prices. Since the price level across manors varied by nearly two to one potentially transport costs were very high.

The price of grain moved up and down sharply from year to year. Thus the national average price between 1300 and 1349 ranged from a low of 3.61 s. per quarter to a high of 16.4 s. per quarter, a range of more than four to one. Transport costs for grain – wages, horse feed, and horse capital costs – do not seem to have increased much in years of grain scarcity. There is no correlation, for example, between cart horse prices and grain prices. And there was little correlation between wages and grain prices. If prices were low on some manors largely because they were in grain exporting areas and the price gap represented the transportation cost to the ultimate grain consumers then the price gap in absolute terms should be the same whatever the grain price. On the other hand, if the price level differences were just caused by measurement or quality differences then the price differences should instead be proportionate to the general level of prices. To test which of these factors was the major explanator of the observed price level differences I estimated the coefficients of the regression

$$\frac{P_{it}}{DECP*_t} = g + h\left(\frac{P*_t}{DECP*_t}\right) + e_{it}$$

for manors with at least 10 price observations separately for manors with average prices below 75% of the national level, 75-85%, 85-95%, 95-105%, 105-115%, and greater than 115% of the national level. If the main reason grain prices differed between manors was transport costs and not measurement issues, then g will be estimated as positive or negative depending on the average price level of a manor, while h will be estimated as 1. On the other hand, if the price level differences were caused by measure and quality differences, then g will be estimated as 0, and h as the level of average prices in each manor. The prices are normalized to the average price for grain in each decade to control for changes in the general price level, which would cause *h* to be biased upwards. Table 3 shows the resulting estimated intercepts and slopes for

Table 3: The Causes of Price Level Differences

Price Relative to Market	Manors	Observations	Average Price relative to Market	Intercept (g)	Standard Error of Intercept	Slope (h)	Standard Error of Slope
<.75	6	168	0.736	-0.145**	.039	0.882**	.037
0.75-0.85	21	900	0.809	-0.152**	.021	0.968	.020
0.85-0.95	40	2,071	0.912	-0.051**	.013	0.961*	.012
0.95-1.05	59	2,523	1.004	0.013	.009	0.991	.009
1.05-1.15	39	3,716	1.059	0.049**	.008	1.014*	.007
>1.15	6	459	1.251	0.010	.034	1.243**	.033

Note: A ** indicates that the intercept is significantly different from 0 at the 1% level or the slope is significantly different from 1 at the 1% level. A * indicates that the intercept is significantly different from 0 at the 5% level or the slope is significantly different from 1 at the 5% level.

manors grouped by their average price relative to the national price. As can be seen there is evidence that the average price differences are the product of **both** differences in transport costs and differences in bushel sizes or grain quality. In the group of six manors with prices averaging 25% above the national level the regression suggest that this is all measurement and quality differences. For the low price manors, however, the evidence is that the bulk of the price differences comes from transportation costs. Overall, however, Table 3 suggests that transport costs were causing differences in prices in the range of about 20% of the average price, much less than the raw average difference in local price levels of about 50% of the national price level. This explains why local prices could depend only on the national price level.

4. Storage Within the Year – Feast and Famine?

Markets operate not just across space, but also across time. McCloskey and Nash (1983) looks at the price rise for grains between harvest as an indicator of the interest costs of storage. In an efficient grain market the rise in prices between harvests should just equal the storage costs. Thus if P_k is the average price of grain at day k in the year beginning the day after grain from the new harvest first becomes available, then we have to have

$$P_k \quad = \quad P_0(1+r+d)^k$$

where r is the interest cost per day, and d is the storage cost per day measured as a fraction of the value of the grain.

By looking at cases where prices for the same grain are reported for the same place at different times in the year McCloskey and Nash find that all the grains – wheat, rye, barley, and oats – exhibited very large price increases in the course of the harvest year. They estimated that wheat prices before 1400, for example, rose by an implied 27-43% over the year. Rye, barley and oats prices were estimated to rise even more. This implies that in the medieval period there was feast after the harvest followed by famine later in the year. Since, as we shall see below, the underlying interest rate in medieval England was never much more than 10% this implies great inefficiencies in the grain market.

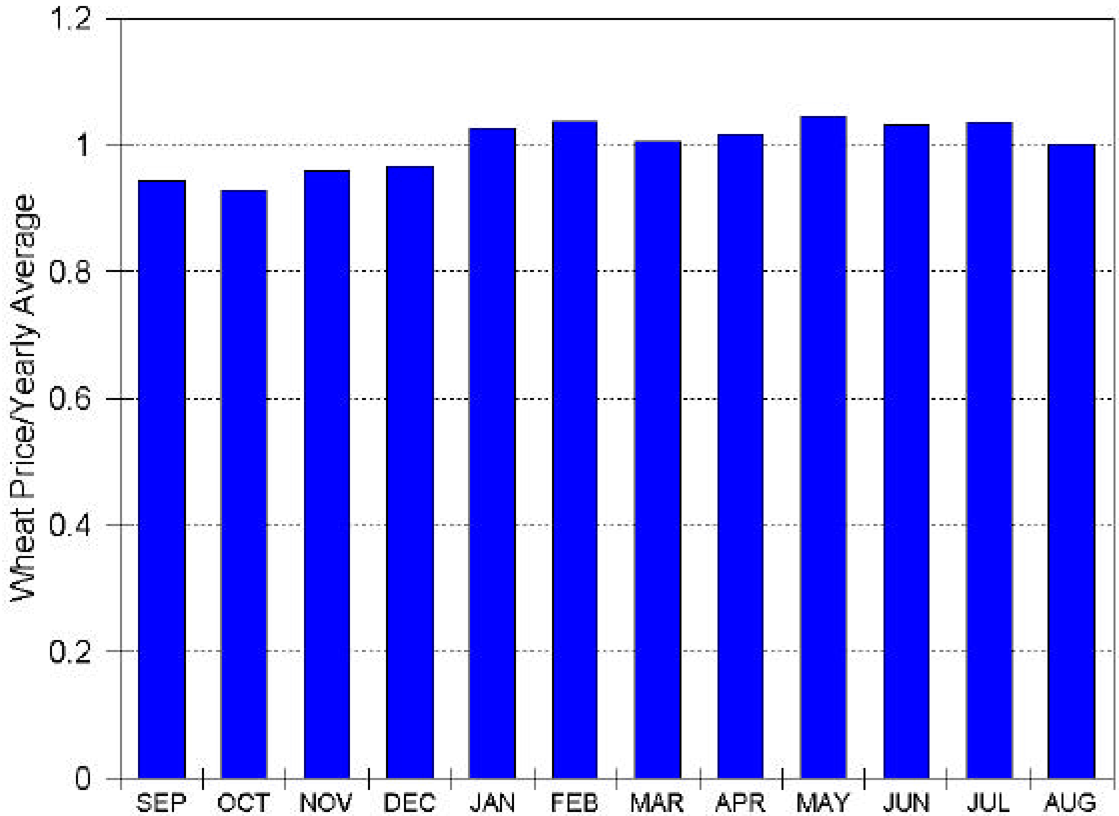
The method McCloskey and Nash use to extract the average price rise from the observations on sale prices by day within the year, however, does not utilize all the information available. For they restricted themselves to the small number of cases where a manor reported two or more prices on specific days within one harvest year. The estimates they get all have very little precision, even though they omit outliers. Here I use a different method which allows me to utilize much more data, and to get more precise estimates of the price rise between harvests. I also have obtained additional data from the papers of Lord Beveridge, and from printed sources.

We saw above that local prices are closely tied to the national price level. Recognizing this, for each observation where the price of grain within a specific part of the year is given, I construct a normalized price that is the local price relative to the national price. Thus if P_{ijkt} is the price at manor *i* of grain *j* on day *k* in year *t*, and P^*_{jt} is the national average price for grain j in harvest year t, the normalized price for each observation is

$$Z_{ijkt} = P_{ijkt}/ P^*_{jt}$$

Dividing the price by the average price for the year removes the effect of the large year to year swings in grain prices, and allows me to use single observations from a manor in a year to estimate the rise in prices. Figure 3 shows the average wheat price in each month in England for the years 1264-1349 constructed in this way. As can be seen there is a rise in average prices between September and July of only 9.8%. Annualized this implies a rise in wheat prices of only

Figure 3: Monthly Average Wheat Prices, 1263-1349



Source: See text.

11.9%.[9]

To measure the annual rate of price increase between harvests I estimate the coefficient b in

$$\ln Z_{ijkt} = a_i + bDAY_{ijkt} + e_{ijkt} \qquad (4)$$

where DAY_{ijkt} is the day of the observation, starting with September 1 equals 1, and running until day 334 (August is excluded because prices clearly begin to fall sometime in August, as can be seen in figure 2). The a_i allow for the difference in measured price levels at different locations. In the absence of a national rye price index, rye prices were normalized using the closest substitute, wheat. Malt is sprouted barley used in making beer, so malt prices were normalized using national barley prices. b will be the average daily rate of price growth for grain. The parameters were estimated for three periods: 1263-1349, 1350-1599, and 1600-1703.

Later observations of prices by week in England shows strong serial correlation in prices across the year (Bright (1856)). Thus an observation of wheat prices at Cuxham on October 1 will not have an independent error term from on observation of wheat prices 5 days later at Cuxham on October 6, or even from an observation on October 1 in Feering in Essex. For some months I have one observed wheat price, while for others I have as many as 22. OLS will thus understate the standard error of the estimate. I control for this in estimating equation (4) by using weighted least squares, where the weight for each observation is the inverse of the number of observations on the price of that grain in the month in question.[10]

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[9] Note also that there is no sudden rise in prices after harvest as Persson (1996) finds, such a sudden rise being inconsistent with efficient storage. Place fixed effects were used in estimating the monthly prices.

[10] Blunt and Cannon (1998) looking at the price rise in the years 1264-1400 with the Thorold Rogers data use different procedures but derive results that are broadly similar to these.

Table 4 shows the estimated annual percentage price rise for each period for wheat and rye, barley and malt, and oats as well as the upper and lower 5% confidence limit on these estimates. Despite the great body of price evidence which I am able to muster from Rogers and other sources, it is still hard to get a very precise estimate of the annualized rise in grain prices between harvests. I can say for sure that McCloskey and Nash's estimates of a 27-43% annual price increase for wheat before 1400 is too high. The best estimate for the years before 1350 is of a wheat and rye price rise between harvests equivalent to an annual rise of 12.5%, and of a price rise between 1350 and 1599 of 9.2%, with finally a price rise from 1600-1703 of 6.6%. For barley and oats the estimates are of much greater price rises in the years before 1350, but the estimates are much less precise because there is less data, and because the observations are noisier. The last rows of table 4 show a pooled estimate of the average rate of price increase for all the grains. Overall what these estimates show is that by 1350 there is no sign of the alleged feast and famine character of the medieval grain market. Price increases across the harvest year are modest. For the years before 1350 the feast and famine phenomena does seem to appear for barley and oats, but as noted the estimates here are very imprecise.

Because the date of many of the prices are only given to the nearest month or months there will be a downward bias in the estimated increase in prices. Table 4 also shows the average expected error in the date of the price due to incorporating prices where a range in days within which prices fell was given. As can be seen on average there will be about a 5 day error in the date of the price. This will bias the estimated value of b down. But the bias will be very modest. The estimated b values need to be multiplied by between 1.005 and 1.02 to correct for the errors in variables bias.

Table 4: The Estimated Within Year Rise in Grain Prices, 1263-1703

GRAIN	Period	Average Date Error (days)	N	Lower Bound	Best Estimate	Upper Bound
Wheat and Rye	1263-1349	5	1,567	6.9	12.5	18.4
Wheat and Rye	1350-1599	3	2,270	3.6	9.2	15.1
Wheat and Rye	1600-1703	5	820	1.7	6.6	11.7
Barley and Malt	1268-1349	6	625	13.6	28.4	45.0
Barley and Malt	1350-1599	6	726	-6.8	3.9	15.9
Barley and Malt	1600-1703	6	330	-1.9	6.4	15.4
Oats and Drage	1264-1349	4	419	16.8	37.5	61.8
Oats and Drage	1350-1599	6	285	0.3	13.7	28.9
Oats and Drage	1600-1703	4	703	19.5	28.0	37.0
All	1263-1349	5	2,611	14.6	20.6	26.9
All	1350-1599	4	3,281	4.0	8.7	13.7
All	1600-1703	5	1,844	8.8	12.7	16.7

Notes: The lower and upper bound estimates are the 5% confidence intervals.

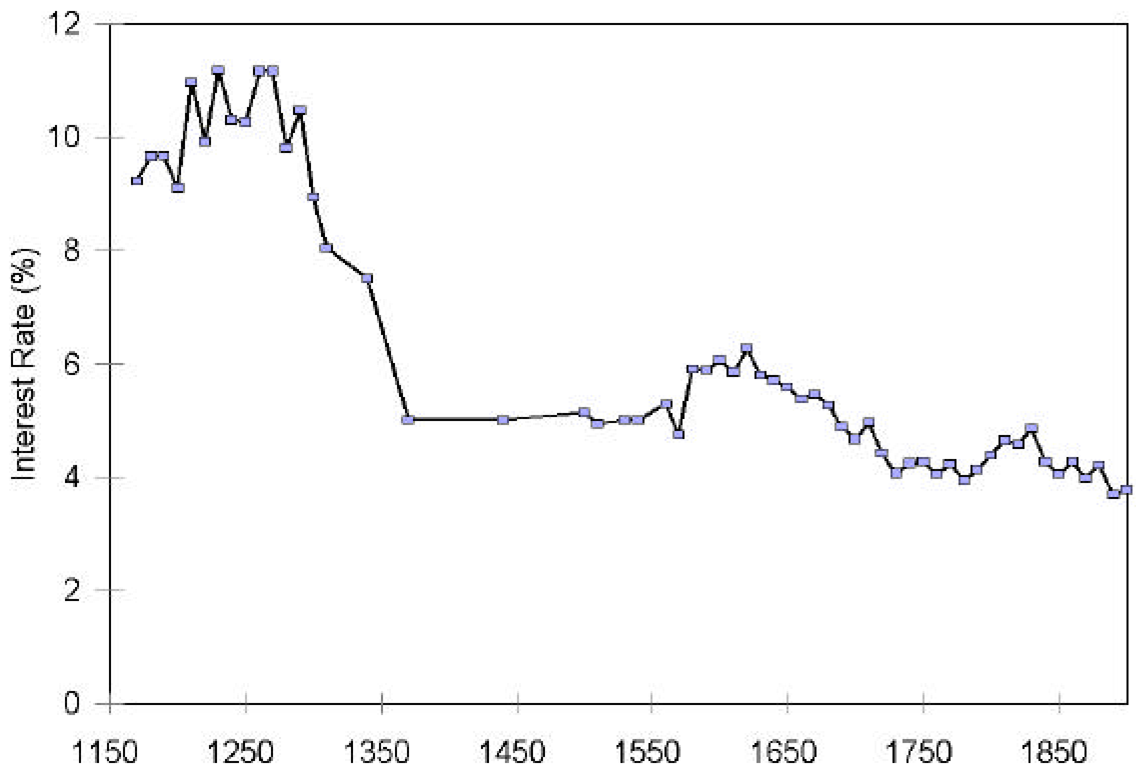
Sources: Rogers (1866, 1882, 1888), 5,477 observations. Gras (1915), 1,166 observations. Beveridge Papers, Boxes G2, P2, 731 observations. Campbell, Galloway, Keene and Murphy (1993), pp. 200-202, 77 observations. Farmer (1988), pp. 739-40, 18 observations.

Storing grain to sell later in the year had two costs. The interest cost of the capital tied up in the grain and the physical costs of storage. The storage cost had two main elements. First was barn space. This was rented in the middle ages, and for wheat in London cost about 1.3-3.8% of the value of the grain at the average price of wheat per year circa 1300 (Campbell, Galloway, Keene and Murphy (1993), pp. 101-103). Outside London the costs would presumably be lower. Second there was the cost from spoilage, and from losses to mice or rats. Evidence from the nineteenth century suggests that less than 3% of grain would be lost in this way per year. Thus the total storage cost was no more than 5% of the average price of wheat per year.

The underlying interest cost of capital is estimated from the rate of return on perpetual annuities secured by land in England. Figure 4 shows this rate from 1175 to 1914. As can be seen there is a relatively sharp decline in interest rates sometime between 1300 and 1400, with the preceding rates of return averaging 10-11%, and those following about 5%. This major decline in rates of return should show up in the size of the price rise in grains between harvests if we have an efficient grain market. The price rise within the year should be smaller in the years after 1350.

A very rough accounting would suggest the profits from storing grain within the year as shown in table 5. Particularly in the earliest period the estimate is that holding grain offered a return about 5% above the cost of the storage. Is this a sign of market failure? I show below the kind of risks involved in such storage, which were considerable, and which would imply that there had to be a premium offered for such activity in the absence of complete risk diversification.

Figure 4: The Rate of Return on Capital, 1175-1900



Source: Clark (1998b).

Table 5: The Estimated Net Gains from Grain Storage within the Year

Period	Average Annual Price Gain	Interest Costs	Storage Costs	Net Average Gain from Storage
1264-1349	20.6	10.5	5.0	5.1%
1350-1599	8.7	5.0	5.0	-1.3%
1600-1703	12.7	5.5	5.0	2.2%

5. Storage Between Years

An efficient market should not only arbitrage excessive price differentials between locations, or excessive price increases within the year, it should also arbitrage price differences between years. Was grain stored in the medieval grain market in years of abundant yields to be sold later when prices were higher? Or was it an economy where, as McCloskey and Nash (1983), Campbell, Galloway, Keene and Murphy. (1993), and Persson (1996) believe, there was little storage of grain from harvest to harvest? And if there was storage, was it at efficient levels?

Was There Storage Between Years?

One measure of the extent of storage is the autocorrelation of prices compared to the autocorrelation of yields. Suppose we postulate that the current price is determined according to the formula,

$$lnP_t \quad = \quad a + bln(Y_t + Z_{t-1}) + e_t \tag{5}$$

where Z_{t-1} is the amount of grain stored from the previous year. Suppose that grain was never stored between harvests. The years for which we have grain prices run from Sept 29 to Sept 28. That is, the years begin after the harvest has been brought in. Thus the price in 1348 will depend mostly on the yield in the harvest of 1348 if there is no storage from year to year. That is

$$lnP_t \quad = \quad a + blnY_t + e_t \tag{6}$$

If we postulate the connection between yields in year t-1 and year t is

$$lnY_t \quad = \quad g + hlnY_{t-1} + u_t \tag{7}$$

then it follows that,

$$lnP_t \quad = \quad (a+bg-ah) \quad + \quad hlnP_{t-1} \quad + \quad (e_t \quad - \quad he_{t-1} \quad + \quad bu_t) \qquad (8)$$ [11]

Now using an index of annual wheat yields for 162 years from 1208 to 1453 we find a very low yield autocorrelation of only 0.16 on average. Wheat yields in one year are a poor predictor of yields in the next year. That should imply in the absence of storage that prices show a similarly weak autocorrelation. But the estimated connection between prices when equation (8) is estimated by OLS is much closer. For wheat, for example, between 1208 and 1453 it is 0.48. When this parameter is estimated by OLS the estimate of the coefficient on lnP_{t-1} will be biased downwards since lnP_{t-1} will be negatively correlated with $-he_{t-1}$. But the downwards bias will be modest where h is small.[12] Table 6 shows the estimated autocorrelation of yields and prices for various periods from 1208 to 1749, where the prices first have long term price trends such as the upward movement of 1520-1620 removed.[13] As can be seen the autocorrelation of prices is always much greater than the autocorrelation of yields. This suggests that grain storage between years was always taking place, even in the thirteenth century.[14]

More storage should cause an increased autocorrelation. As can be seen there is little sign of any long run increase in grain price autocorrelation in England up till 1750. After 1750 reported grain prices are from calendar years not harvest years so that the autocorrelation should anyway increase.

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[11] This result follows since $lnP_t = a + b(g + lnhY_{t-1} + u_{t-1}) + e_t$, and since $lnP_{t-1} = a + blnY_{t-1} + e_{t-1}$, so that $lnY_{t-1} = (lnP_{t-1} - a - e_{t-1})/b$, the connection between lnP_t and lnP_{t-1} follows.

[12] There is also a compensating upward bias in the correlation created by the fact that the account year used by Farmer to construct yearly prices does not coincide exactly with the harvest year. Thus the prices of 1348, for example, include some prices determined by the harvest of 1349 in the last month of the year. This would drive up the autocorrelation by about .083.

[13] This was done by including in the regression year trends up to a cubic term.

Table 6: The Autocorrelation of Yields and Prices

Century	Wheat Yields	Wheat Prices	Barley Prices	Oats Prices	Average Grain Prices
1208-1349	0.19 (0.16)	.51 (.09)	.48 (.09)	.48 (.09)	.49 (.05)
1350-1499	0.12 (0.10)	.38 (.08)	.42 (.07)	.34 (.08)	.38 (.04)
1500-1620	-	.40 (.09)	.36 (.09)	.19 (.09)	.32 (.05)
1620-1750	-	.60 (.07)	.51 (.08)	.41 (.08)	.51 (.04)

Notes: The numbers in brackets are standard errors.

[14] There were currency devaluations which would affect the autocorrelation of the raw prices, such as in 1351, 1411 and 1464. But by calculating prices relative to long term trends I should be correcting for long term movements in currency values.

How much storage was taking place in the medieval period? The raw autocorrelations do not reveal this. But we can get an idea in the following way. Suppose we take the years where the previous price was at or above the average for the last 10 years. Then in such a year there should be no incentive to store grain, since the price would have to be expected to be 10-15% higher next year to make storage profitable. And the year to year connection of prices predicts that in such years prices will be predicted not to rise in the subsequent year. Thus if we use the 82 years where the previous price was at or above average we can estimate the parameters a and $ß$ in equation (5). The estimate for these years is, for price normalized by the average price of the last 10 years,

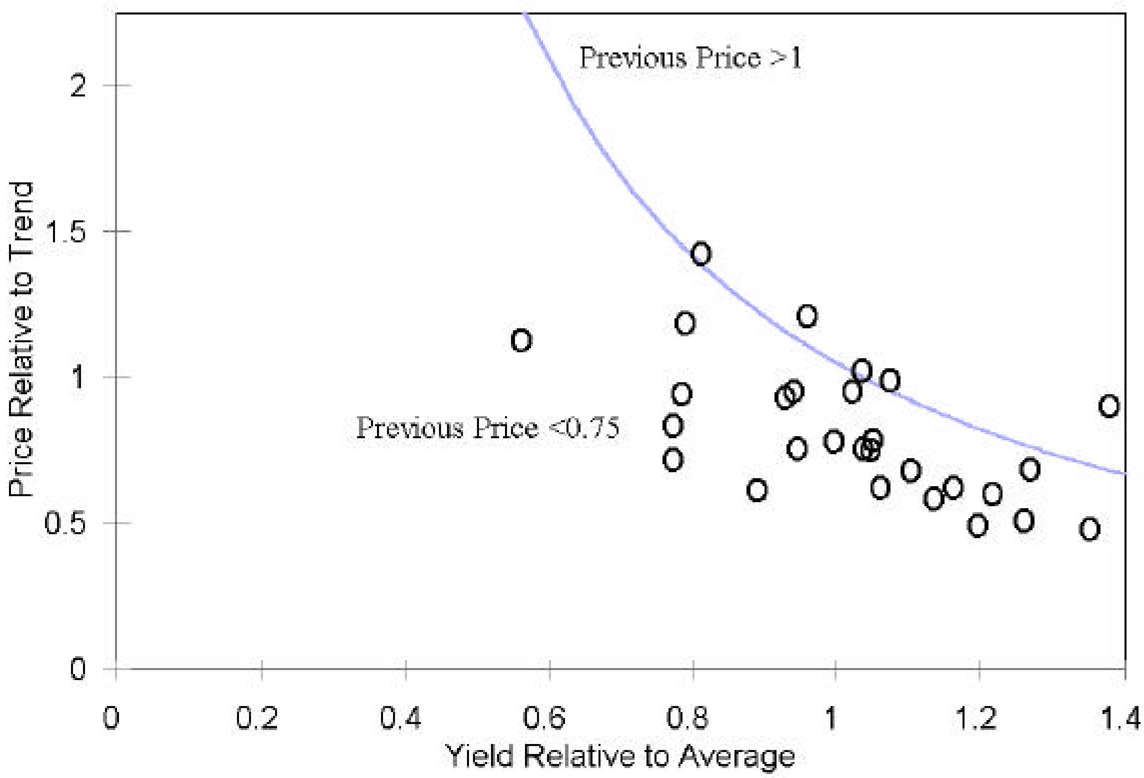
$$\ln P_t = \underset{(0.026)}{0.050} - \underset{(0.136)}{1.342} \ln Y_t$$

$$R^2 = 0.56$$

Figure 5 shows the estimated connection between prices and yields for these years. The figure also shows the 32 cases where the previous year's price was less than 0.75 of the average price of the last 10 years. As can be seen prices tend to be lower than expected from the regression line in these years given the yields.

We can estimate on average how much inventory would be needed to place observations classified by the level of prices in the previous year onto the regression line estimated for the cases where there was no storage. The results are shown in table 7. They suggest that when prices were significantly below average in the previous year storage of wheat into the next year was of significant magnitude relative to average yields. Thus when the previous price was less than 0.6 of the trend the average implied inventory was 40% of typical yields. For prices

Figure 5: Wheat Prices and Yields, 1208-1453



Note: Prices are measured relative to the average of the previous 10 years. Yields are measured relative to average yields in the years 1208-1453.

Table 7: Previous Prices and Implied Storage, 1208-1453

Previous Price relative to Average	N	Average Current Price (P_t)	Average Current Yield (Y_t)	Average Implied Inventory (Z_{t-1})	Standard Error of Inventory Estimate	Average Previous Yield (Y_{t-1})
<0.6	9	0.65	1.08	0.40**	0.04	1.22
0.6-0.7	10	0.96	0.92	0.19**	0.06	1.20
0.7-0.8	26	0.91	1.04	0.12**	0.04	1.12
0.8-0.9	31	0.92	1.00	0.13**	0.02	1.06
0.9-1.0	26	0.96	1.02	0.09**	0.03	1.02
>1.0	78	1.21	0.95	0.01	0.02	0.88

Notes: Yields are normalized to equal 1 on average in the years 1208-1453. Prices are normalized by the average of the previous 10 years prices.

** indicates the levels of inventory in these years were significantly greater than 0 at the 1% level.

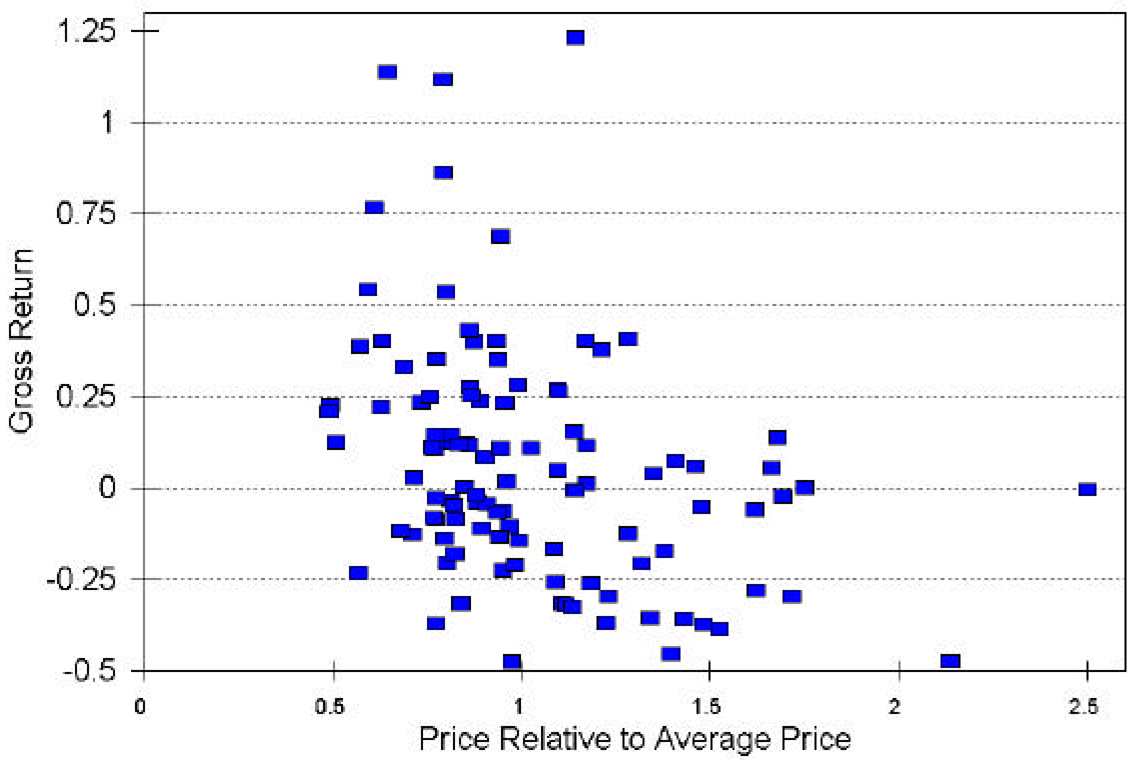
between 0.6 and 1.0 compared to the past ten years the prediction is again that these years were associated with inventory carryovers, though of much smaller magnitude. Since we do not have comparable evidence on yields in England again until the years after 1883, by which time imports were of enormous significance as were inventories held abroad, we cannot compare implied storage in the medieval period with storage later.

Efficient Storage?

While we see above ample evidence for even the earliest years of storage of grain from year to year, was it storage at efficient levels? Did the storage eliminate all profit opportunities? The gross profit rate from storing from year to year is given by $\Delta p_t/p_t$, where $\Delta p_t = p_{t+1} - p_t$. If the market is efficient there should be no predictable set of prices for which $\Delta p_t/p_t$ exceeds the interest cost of capital by more than the storage cost of grain. There should be a lower bound below which no price is observed, because once prices fall that low the incentive should be to store grain and hold to the next year. For the lowest observed prices are profits in excess of interest and storage costs predictable? Testing this is difficult because of the enormous amount of noise in grain prices. Thus figure 6 shows the gross return from holding wheat from year to year in 1220-1349. As can be seen the gross return from holding grain is clearly higher at lower prices, but whether the return systematically exceeds the normal return on capital is going to be very hard to test.

To test this we need to look at a set of low prices sufficiently large that we can control for sampling errors. Thus I took the set of prices where the current price was only 80% or less of the average price over the previous 10 years, and calculated the average gross return from buying grain in these years. Table 8 shows the results of this estimation for the years 1220-1349, 1350-

Figure 6: Gross Return from Holding Wheat as a Function of Price, 1208-1349



Note: The price in each year is measured relative to the average price for the preceding 10 years.

1499 and also for comparison for 1620-1749. These periods were chosen as ones where grain prices showed no long term trend. The large amount of noise in price movements shows up in the large standard errors in the estimated average returns from holding different grains from one harvest year to the next. Thus the gross return for wheat is estimated at 22.3% for the years 1220-1349, but with a standard error of 7.4%. Since based on interest and storage costs we would expect the gross gain from storage to be between 15 and 16% in these years, the actual returns are not significantly higher.

For these years we find similar results for barley and oats. Since wheat, barley and oats were substitutes, and so their prices tended to be fairly highly correlated from year to year, the similarity of the estimated gross return for all three grains in 1220-1349 does not tell us much more than the gross return for wheat itself. The data does not allow us to conclude with any confidence that there were excess returns from holding grain when prices were low, even in the years before 1350. Even with the benefit of all the data from the years 1220 to 1349 the variance in returns from year to year is so high that it would be very hard for anyone at the time to have a clear idea of what the expected return was.

Further the variance of returns made this a much more risky investment than investing in rent charges or land, which are the assets which provide the estimate of the interest cost of capital. Thus even though buying grain in years of very low prices offered higher returns on average than did these safe assets, we would expect the returns would have to be much higher. Finally in the years of the lowest prices there is evidence of significant storage of grain. Grain in England was stored in specially constructed stone barns which were elevated above ground to keep out damp and vermin. When prices got very low storage costs may have risen sharply as the available fixed storage capacity was exhausted.

Table 8: Gains from Storage for One Year when the Price Falls Below 80% of Average

Grain/Period	N	Average Price relative to previous 10 years	Average Gross Return (%)	SE of Gross Return
Wheat				
1220-1349	25	0.68	22.3	7.4
1350-1499	33	0.69	18.8	4.7
1620-1749	29	0.69	7.2	4.2
Barley				
1220-1349	26	0.67	29.3	7.1
1350-1499	22	0.71	11.6	5.6
1620-1749	21	0.72	12.7	5.0
Oats				
1220-1349	19	0.70	22.4	7.0
1350-1499	21	0.75	12.8	4.3
1620-1749	12	0.74	17.5	5.6

Notes:

6. Conclusion

The above tests suggest that from the earliest period we observe, the thirteenth century, the grain market was spatially extensive and relatively efficient. The complete determination of local prices by the national price level suggests that transport costs had to be low, and that grain shipments were responsive to local deviations of price from the national price. This does not mean that the market worked perfectly. That would imply that the R^2 in the regressions explaining local prices was 1. But the market worked pretty close to perfectly. If I pool the data and just regress

$$lnP_{jt} \quad = \quad a_j \quad + \quad b\ lnP_t^* \quad + \quad e_{jt}$$

for the 227 manors I have data on wheat prices before 1500 I get an R^2 of 0.861. Thus the national price level explains on average 86% of the variation in local prices, even though these manors are spread across England and Wales from Devon in the South West, to Troy in Glamorgan, to Jarrow in Durham in the North East. The medieval economy thus offered plenty of scope for regional and individual specialization in production.

The storage of grain within the year seems also to have been relatively efficient. The rise in grain prices between harvests averaged 21% in the years before 1350, which was much higher than later. But the interest cost of capital in this period revealed by land purchases and rent charges was in excess of 10%. Thus to cover interest costs and storage the price rise had to be at least 15% before 1350. The errors of measurement are such that it is not clear that the price rise really did exceed 15%, but even if it did the extra return is small relative to the risks of holding grain for speculative reasons. Grain prices were volatile and could change sharply within the course of the harvest year as new information arrived.

Grain was also being stored from year to year in years when the prices fell, and the amounts of storage for the years with the lowest prices seem to have equaled about 40% of the average annual harvest. By 1350 the amounts of storage were such that our best guess is that storage was at efficient levels. Before 1350 there is weak evidence that purchasing grain in low price years did offer profits above the opportunity cost of capital. But the risks involved, the difficulty of determining that this opportunity existed given the noise in the data, and the problem that the costs of storage would rise sharply once barn space was filled all make this evidence no more than just suggestive.

Thus we see in medieval England the development of an extensive and efficient market for the largest commodity in the economy, grain, by the thirteenth century at least. This development of an elaborate and extensive market occurred despite the legal and social obstacles placed in its way. And this development was complete hundreds of years before the English economy showed signs of modern economic growth.

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