Grain storage in theory and history

By Nicholas Poynder[1]

It is now more than a century since Cunningham denounced Marshall's attempt to expound his *Principles of Economics* in historical terms.[2] Cunningham's attack resulted in a debate over the heart of political economy; parallel to that which set the German Historical School against Menger.[3] Ever since, its disputants have fought to save political economy from the heresies of relativism on the one side, and of rationalism on the other. Their debate has been an outstanding example of the Law of Unintended Consequences. As the belligerents have driven history and economics even further apart, so economic history has become less often to forge for new economic theories, and more often a haven for either *ad hoc* historical descriptions or textbook economic explanations.

The practice of cliometrics illustrates the divisiveness of this century-old sectarianism. Cliometrics should describe no more than the measurement of the past. As such, it was central to classical political economy, which drew many theoretical inferences from the quantitative study of history.[4] Many practicing cliometricians,

[1] This paper evolved out of discussions with Graham Brownlow, Bruce Ca,pbell, Charles Hickson, and Liam Kennedy at the Queen's Universit of Belfast. The resulting arguments were refined through presentations at Edingburgh and Utrecht Universities.
[2] Cunningham 'Perversion of economic history', pp. 491-506; Marshall, 'A reply', pp. 507-19.
[3] For a discussion of the debate between menger and the German Historical School see Hickson, 'Menger's organic view', pp. 5-8; Eucken, *Foundations of economics*, pp. 54-63.
[4] O'Brien, *The classical economists*, pp. 66-7.

however, have by insensible degrees turned this definition on its head. No longer do they quantify history in the service of economics. In a reversal of roles, economics is now pressed into the service of history. The danger therein is well illustrated by recent cliometric research on the seasonal variation of grain prices in medieval England and early modern Europe.

Since the 1920's, economists have puzzled over why, apparently, the difference between the current and expected future price of grain did not equal its marginal cost of storage.[5] Grain prices, they observed, ought to have risen from each harvest by as much as the costs of renting storage space, the depreciation of grain, the foregone opportunity of investment, and insurance. In reality, however, the equation did not hold. Modern evidence did not appear to support the theory that seasonal price variations were equivalent to the costs of storage, because these costs were found to have usually exceeded the seasonal price increases. Working and Brennan, amongst other economists, accounted for this discrepancy by postulating further benefits to grain storage, gained through both long-distance trade and newly-developed financial instruments.[6] In the absence of these factors, by implication, the difference between the present and the expected future grain prices would indeed have equalled the above-mentioned costs.

The validity of this proposition can be tested against a long-term study of seasonal price variations in grain. Cliometricians have displayed ingenuity in devising the means to measure the historical variations in grain prices. They have been content,

[5] This discrepancy was fully elucidated by Davis, Taylor and Working, 'Variations', *passim*; Hobe and Working, 'Post harvest depression', *passim*; Keynes, A treatise on Money, II, Chapter 29, Part iii.
[6] Brennan, 'Supply of storage', *passim*; Samuelson, 'Tpwards a theory', *passim*; Working, 'Theory of price of storage', *passim.*

nevertheless, to assume the equation between expected price increases and the costs of rent, interest, depreciation, and insurance; making further inferences on the strength of its historical validity.

In order to explain English seasonal price variations between 1260 and 1399, for example, McCloskey and Nash assumed their equivalence to "the cost of the barn per bushel plus the percentage rotting in storage plus the expected percentage loss of capital due to falls in the price per bushel plus the opportunity cost of the interest foregone on the sum expended on the bushel."[7] Between harvests, the three relevant costs were rent, depreciation, and interest. Latterly, they qualified the equation by adding the cost of insurance because "prices did not march up mechanically".[8] The same assumption was made by Clark, who upon discovering that the fourteenth-century interest rate was less than half what McCloskey and Nash had inferred, cited as explanation "an unknown but presumably substantial risk premium because the return on storing grain varies enormously from year to year."[9] Persson defined storage costs with regard to early modern Europe, as "the waste of grain, the income foregone by holding stocks, i.e. the prevailing interest rate, and risk premium."[10] Ó Gráda similarly observed that in pre-Famine Ireland, potato and grain prices rose seasonally with "storage charges and risk premia, pure and simple."[11]

[7] McCloskey and Nash, 'Corn at interest', p. 178.
[8] *Ibid*., p. 183.
[9] Clark, Çost of capital', p. 275.
[10] Persson, 'Seven lean years', p. 700.
[11] Ó Gráda, *Ireland*, p. 106.

Expressed formally, cliometricians have assumed the validity of Equation 1 to explain the seasonal variation of grain prices throughout history:

$$\frac{E}{C+S} = 1.0 \text{ if } S = R + I + D + P$$

Equation 1 *The marginal cost of grain storage*

when E is the expected price at the season's end, C is the price at the season's beginning, S is the storage cost of a whole season, R is rent, I is interest, D is grain depreciation and P is a risk premium. In other words, grain prices tend to rise seasonally because grain will be stored only when its expected future price equals the sum of its current price and these storage costs.

The assumptions made by these cliometricians about the theory of grain storage are founded on the speculation of their economist predecessors. But instead of taking the evidence of history in order to ask whether the theory was appropriate, cliometricians have sought to test the evidence by the theory. McCloskey's onetime retort to critics that: "We are not testing economics; we were using it to cast light on medieval history", was entirely consistent with this approach.[12]

In so doing, she, and other cliometricians, have apostasised from marshall's precept that (as he said) "if we are dealing with the facts of remote times we must allow for the changes that have meanwhile come over the whole character of economic life: however closely a problem of today may resemble in its outward incidents another of recorded history, it is probable that a closer examination will

[12] McCloskey, Çonditional economic history', p. 130.

detect a fundamental difference between their real characters."[13] Marshall's concern, I shall argue for the remainder of this paper, was borne out by the storage of grain in both theory and history. If cliometricians ignore Marshall, who as Schumpeter rightly said was a better historian than many of his critics, they risk being not historical, but instead heretical economists.[14]

II

Equation 1 can be measured against the evidence of English history. Pioneering investigation of these variations was made by McCloskey and Nash, based on the premise that, as the equation predicts, grain prices should have been lowest immediately after the harvest, and should have risen until the succeeding harvest before falling back to their harvest price. With this foreknowledge, they used the evidence collected by Rogers for wheat, barley, and oats prices, to illustrate that medieval seasonal price variations for grain were inferable from the average monthly rate of change within each harvest year. Table 1 below replicates their method for 1260-1399, and four successive time periods. The harvest year throughout was taken to start from September. To isolate the seasonal element, the long-term rate of inflation was deducted.

[13] Marshall, *Principles of economics*, p. 774.
[14] Schumpeter, *History of economic analysis*, p. 822.

Table 1 *Seven centuries of seasonal price variations in English grain*

Period	*Mean seasonal % increase (on September price)*		
	Wheat	Barley	Oats
1260-1399	33.1	39.2	52.1
1400-1539	9.0	-6.9	28.5
1540-1679	2.7	1.1	23.9
1680-1819	-3.3	-0.5	3.8
1820-1959	8.0	-6.6	13.4

Notes: On the method, see McCloskey and Nash, 'Corn at interest', pp. 178-82. Long-term inflation was calculated by the geometric mean of annual price changes.

Sources: Rogers, *History of agriculture*, I, III and IV, pp. 4-170, pp. 4-118 and pp. 5-198; Beveridge, *Prices*, I, pp. 83-4; L.S.E., *Beveridge papers*, E 19 and E 25; *Agricultural statistics*, (1948) II, p. 22; (1950) II, p. 17; (1955) II, p. 37; (1957), p. 121; (1958), p. 104; (1959), p. 120; (1960), p. 100; (1961), p. 102.

The table reveals a decisive fall in seasonal price variations between the first period and all four of those succeeding it.[15] A comparatively low seasonal variation in grain prices in early modern times also obtained in continental Europe, as Table 2 illustrates. Because southern European grain ripened earlier, results are given commencing from both August and September.

[15] The untypical movement of barley prices in Table 1 can be attributed to malting. From 1970-5 English barley showed a seasonal price variation of -6.9 per cent. Malting barley is bought early in the year, after which the quality and quantity of barley at market declines, lowering its price. See Knell and Sturgess, *British malting barley*, p. 148, p. 197 and p. 201.

Table 2 *Seasonal price variations of wheat in France, Germany, and Italy (1550-1699)*

City	*Mean seasonal % increase (on August and September prices)*	
	From August	From September
Cologne	7.1	5.2
Paris	2.2	4.1
Sienna	5.0	4.2
Toulouse	12.5	7.1

Sources: Cologne: Ebeling and Irslinger, *Mitteilungen*, pp. 539-614; Paris: Baulant and Meuvret, *Prix des cereals* I-II, pp. 45-81 and pp. 4-45; Sienna: Parenti, *Il mercato del grano*, pp. 38-41; Toulouse: Drame et al., *Un siècle de commerce*, pp. 106-112.

It is also possible to estimate all the storage costs of grain designated by Equation 1above, except insurance. In modern times, these can be specified with reasonable confidence.[16] Research by Hobe and Working in the 1920's suggested that annual storage in contemporary America cost around 20.2 per cent the price of wheat at harvest time.[17] In the 1820's Jacob conducted research on the Baltic grain trade, including storage costs at Hamburg and environs.[18] The combined annual rent,

[16] Modern insurance premia against flood, fire and theft are ascertainable; but these form an incomplete picture of total insurance, including the premium on unexpected price changes.
[17] These estimates were based on Chicago. Davis, Taylor and Working, ' Variations' , p. 267; Hobe and Working, 'Post-harvest depression' , pp. 21-2.
[18] Jacob, *Tracts relating to the corn trade*, p. 80 and p. 173.

depreciation, and interest came to 15.4 per cent the price of wheat. This was probably above the London commercial storage cost, where the rate of interest was lower.[19]

Calculating early modern storage costs is less straightforward. Robert Loder's farm accounts offer a good starting point. The contemporary interest rate stood at 5.8 per cent.[20] Acceptable profits were higher.[21] For example, Loder calculated his barn's rent as 10 per cent its construction cost; equal to 6.3 per cent the value of wheat it could store at that year's prices.[22]

Depreciation cannot be calculated precisely, but between 1612 and 1620 Loder took great care in recording its extent and causes. From his accounts, he lost 3 per cent his wheat and 0.3 per cent of his malt through a combination of theft, rotting, shrinkage, and market tolls.[23] Loder's grain was presumably stored less than annually on average, so these rates are under-estimations. Depreciation's chief element, however, was smutting. Smut primarily affected ripening corn. As Loder stored his grain unthreshed, pre-storage losses were a sizeable component of total depreciation.[24]

[19] The Prussian interest rate of 4.9 per cent was higher than the contemporary yield on consols of 3.7 per cent: Homer, *History of interest rates*, p. 164 and p. 259.
[20] Clark, ' Cost of capita' , p. 272.
[21] Smith observed that the profit rate equalled about twice the current interest rate in the late eighteenth century. He speculated that a higher rate of interest might lead to a proportionally lower rate of profit: *Wealth of nations*, p. 87.
[22] Fussel, *Robert Loder's farm accounts*, pp. 158-9. The calculation was based on the average Michaelmas price of wheat between 1600 and 1619 at Cambridge: Rogers, *History of prices*, 6, pp. 15-32.
[23] Fussel, *Robert Loder's farm accounts*, pp. 29-182.
[24] Dondlinger, *Book of wheat*, p. 159.

His annual depreciation rate was unlikely therefore to have exceeded 5.0 per cent; making the total storage cost 17.1 per cent.

Was this typical? Interestingly, Loder's evidence indicates substantial farmers like himself incurred above-average storage costs. Interest net of risk should have been identical for all farmers, but depreciation and rent probably cost substantial farmers more. Their grain was generally barn-stored. Most pre-modern storage was in open-air ricks.[25] Barns, as Loder made clear, were considered three times as constly to store in as ricks. Grain on farms employing wage labour, may have been stored in barns as protection from theft, which agitated Loder, as it had Tusser in the sixteenth, Grosseteste in the thirteenth and Columella in the second centuries.[26]

McCloskey believed that the ,edieval cost of storing grain could not be estimated independently from seasonal price variations. She wrote: "It is of course not possible to construct direct measures by adding up such components as the rate of interest and the rate of rotting: medieval bond rates were difficult to interpret and no one knows how much of a peasant's crop rotted."[27] But recent research makes an estimate feasible.

[25] Concerning seventeenth-century England, Markham wrote: "of necessity he [the husbandman] must be inforced to stack much, or the most part of his corn without doors.' *Markham's farewell*, p. 70.
[26] Fussel, *Robert Loder's farm accounts*, p. 127, p. 139, p. 161 and p. 163. Tusser wrote: " if thou wilt thrive, loke thy selfe to thy barne", *Hundreth pointes*, f.8. Chaucer said of Reeve: "Wel koude he kepe a gerner and a binne; Ther was noon auditour koude on him winne." Chaucer, *Prologue*, p. 69. A century before, Grosseteste advised : « Give orders to your steward that your granges everywhere are to be well secured after harvest, and that no servant or bailiff is to open them without special order or letter from you or from him until the time of threshing." Oschinsky, *Walter of Henley*, p. 395. Columella, *On agriculture*, I, p. 81.
[27] McCloskey, 'Conditional economic history', p. 128.

Between the fourteenth and seventeenth centuries, storage technology changed little. Moreover, manorial accounts were adversarial, with landlords often charging officials for losses.[28] Without a sound medieval basis for estimating depreciation, Loder's evidence provides the most apt parallel. Assuming its rate has been as high in the fourteenth as the seventeenth century, the remaining two storage costs – rent and interest – require estimation. Clark has calculated the interest rate in fourteenth-century England from the reliable data of perpetual rents, at around 10 per cent per annum.[29] Evidence on barn rent is also forthcoming. In prosecuting their Scottish campaigns, English kings frequently had occasion to hire storage space.[30] For 8,786 quarters stored in 15 town, the cost, quantity and length of storage are recorded: averaging 3.6 per cent the price of wheat per annum. Accordingly, the storage cost for English wheat circa 1300 amounted to approximately 18.6 per cent its value.

Table 3 sets out these costs of wheat storage and contemporary seasonal price variations in the fourteenth, seventeenth, nineteenth and twentieth centuries. McCloskey's equation predicted they would move together. Column (6) suggests they did not.

[28] For example between Michaelmas 1332 and 1334, 55.4 quarters of malt were stored at bBury Abbey's Suffolk manor of Hinderclay. The reeve claimed 1.6 quarters. Had been lost, but was fully charged by the auditor even for this depreciation, Chicago University Library, Bacon 458-9.
[29] Clark, 'Cost of capital', p. 268.
[30] Public Record Office (London), E101 552/14 (1334); 556/7 (1319); 561/9 (1334); 556/8 (1319); 571/10 (1323); 571/14 (1326); 571/17 (1326); 574/25 (1319); 577/10 (1339); 582/9 (1319); 588/8 (1319); 593/5 (1319).

Table 3 *Seasonal price variations of wheat, annual storage costs and their difference (fourteenth to twentieth centuries)*

Century	(1) Seasonal price variation (%)	(2) Annual interest (%)	(3) Annual rent	(4) Annual depreciation	(5) Annual storage cost = (2)+(3)+ (4)	(5) Difference = (1)-(5)
Fourteenth	33.1	10.0	3.1	5.0	14.5	
Seventeenth	5.0	5.8	6.3	5.0	-12.1	
Nineteenth	1.4	3.7	6.9	3.5	-12.7	
Twentieth	4.1	5.6	14.6	0.0	-16.1	

Notes and sources. Sources for seasonal price variations are: 'Fourteenth' = '1260-1399' for wheat in Table 1. 'Seventeenth' = Wheat seasonal price variation at Oxford between 1619 and 1643, in Rogers, *History of* agriculture, 6, pp. 31-52. 'Nineteenth' = wheat seasonal price variation at London, from 1793 to 1801, in London School of Economics, Beveridge papers, I 16. 'Twentieth' = wheat seasonal price variation at Chicago, 1887-1916, in Davis, Taylor and Working, 'Variations', p. 267.

Table 3 implies that seasonal price variations were in excess of storage costs in the fourteenth century, whereas thereafter, storage costs were in excess of seasonal price variations. While storage costs fell noticeably before rising again in modern times, the fall in seasonal price variations was altogether more dramatic.

III

What could explain the failure of seasonal price variations to match over the centuries the inevitable costs of storing grain? Two possible answers may suffice. Either the evidence for grain prices and storage costs presented here is somehow misleading, or the applied theory of grain storage has been misspecified by cliometricians.

Turning firstly to the former possibility, seasonal price variations may have fallen below the annual cost of storage, because bringing the harvest home took a month or more. The transitionary period would pull down the average monthly increase in grain prices. Presumably with the growth of the grain market, the harvest period would become as prolonged as the geographical dispersion of supplies was wide. The utmost extension of this market growth had been achieved by the twentieth century, when Southern Hemisphere imports broke into the Northern harvest cycle midway.

This consideration is not enough, however, to explain all the disparities between columns (1) and (5) in Table 3. The grain market remained highly localized before the late nineteenth century. Hardy's description of the trade in the 1840's, while perhaps overstated, was probably not misleading: "The time was in the years immediately before foreign competition had revolutionized the trade in grains, when still, as from the earliest ages, the wheat quotations from month to month depended entirely upon the home harvest."[31] Contained within the Northern Hemisphere, trade should have left the bulk of the harvest year unaffected until the late nineteenth century. Even the unrealistic assumption of an instantaneous harvest could not account for the opposite disparity between 1260 and 1399, when seasonal price

[31] Hardy, *Mayor of Casterbridge*, p. 183.

variations greatly exceeded storage costs. Prolonged harvests cannot therefore by themselves explain column (6).

A further weakness with the evidence presented above, is that less quantifiable costs to storing grain have not been considered. To keep the rate of depreciation low, it was necessary to ventilate threshed grain. Stores also needed insurance. The cost of ventilation would reinforce, rather than reduce the discrepancies apparent in Table 3. If most grain in pre-modern times was stored unthreshed and outside, ventilation costs would probably increase the differences between seasonal price variations and total costs.

The cost of insurance is more likely to have moved in the opposite direction, with acceptable risk premia decreasing since the Middle Ages. Whether or not risk aversion itself has diminished, one component of risk, the crime rate, almost certainly has.[32] Growth in the insurance market has also made risk-spreading less costly. For example in 1323 Peterborough Abbey lost a £100 stone-and-timber barn, along with 1,300 quarters of grain, to self-combustion: "*propter foenum aquosum et viride infra positum*." (On account of the green, wet grass placed therein).[33] The perceived reduction to theft through barn storage need only have been greater than the higher risk of fire by the cost of the barn themselves. Could an inversion of the ratio between storage costs and seasonal price variations be explained by declining risk premia over the last seven centuries? The answer would appear to be no, because while a high cost of insurance could amount for the difference between columns *(1)* and *(5)* in the fourteenth century, its decline could not account for the low level of seasonal price variations relative to storage costs thereafter.

[32] For a summary of recent research, see Fischer, *The great new wave*, pp. 305-11.
[33] Sparke, *Historiae Anglicanae*, p. 164 and p. 224.

From this discussion of the potential limitations to the data in Table 3, it is now possible to take stock of the possibility that the above evidence of storage costs fails to capture all the elements of Equation 1. Even if market growth and failing insurance charges are taken into consideration, the long-term seasonal variation of grain prices cannot be equated with the combined storage costs of rent, interest, and depreciation. Throughout history, the two halves of the equation have neither been equal, nor changed equiproportionally. Both must be misspecified.

Confronted with the difference between seasonal price variations and storage costs in early twentieth-century America, Working and Brennan, amongst others, argued their theoretical equivalence was justified. They cited as factors for the excess of storage costs over seasonal price variations the effect of long-distance trade, high fixed rental costs, and cheap insurance.

Firstly, imports from Argentina and elsewhere caused grain prices to fall from early summer. Secondly, when stocks were low, the rental cost per unit of grain would fall below its quoted rate. Thirdly, merchants and millers habitually sold part of their stocks forward on the futures market as hedges against early, unexpected price falls. These economists concluded, however, that storage costs still exceeded seasonal price variations.[34] Hence they postulated that storage conferred an additional 'convenience yield'. Kaldor first employed the term to explain why factory owners, to meet unanticipated demand for output, held more plant than was optimal for current

[34] For a summary of these results, see Williams, *The economic function of futures markets*, pp. 33-5. Williams argues that hedging does not serve the purpose of insurance, but instead allows hedgers to increase their current grain inventories through borrowing.

Production.[35] The proximity of their grain elevators to the spot market likewise allowed millers and merchants to grade, process, and deliver grain as advantage dictated. On this foundation of empirical research, the equivalence between price changes and marginal storage costs rested secure.[36] In the absence of these additional factors, Hobe and Working claimed "the price change from fall to spring would be much larger, as is illustrated in domestic wheat prices in many European countries."[37]

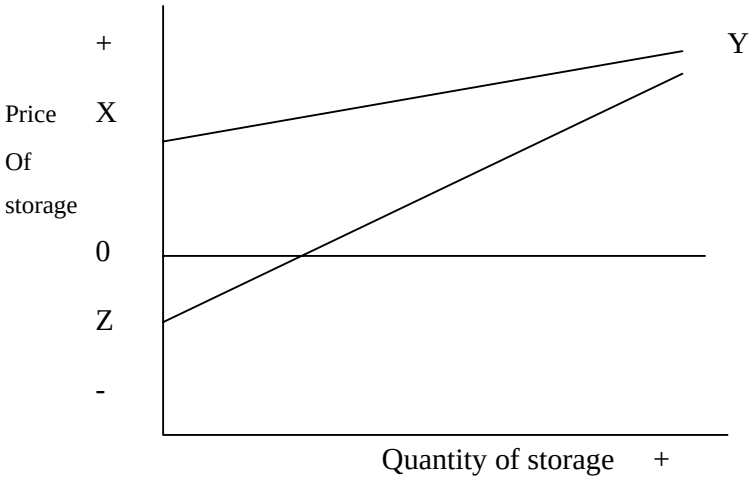
Their claim, expressed as Equation 1, has been endorsed by cliometricians. But it remains no more than speculation. After all, there is no reason for why the convenience yield on grain storage must be a purely modern phenomenon. A high convenience yield can be envisaged without any trade whatsoever. For example, a traveler walks through the desert between oases *(A)* and *(C)* via oasis *(B)*. How much water should be carried from *(A)* to *(B)*? Water is heavy, so presumably the minimum necessary. Would the traveler carry more or less water if there were a chance oasis *(B)* had dried up? Probably more, in which case, even without another soul to trade with, one might find it convenient to store additional goods against additional risk.

Cliometricians have not necessarily been correct, therefore, in assuming that without sophisticated markets, insurance was historically a cost consideration to storage. As a walk through the desert would show, additional storage may increase some risks (such as exhaustion), while reducing others (such as death from thirst). By analogy, grain may be stored either when the sum of rent, interest, and depreciation are less than, equal to, or greater than the expected increase in price between the

[35] Kaldor, 'Speculation', p. 6.
[36] Davis, Taylor and Working, 'Variations', pp. 266-7 and pp. 272-4.
[37] *Ibid*., p. 271.

present and a future time, depending on the ratio of convenience to risk in storage. If the convenience is greater than the risk, then storage will occur even when the anticipated future price increases at a slower rate than rent, interest and depreciation; if it is less than the risk, then *vice versa*.

These alternative scenarios can be represented as supply schedules: *XY* and *ZY* in Figure 1. Supply commences at *X* if, as cliometricians have claimed, grain is found to be worthwhile storing when the price increase is expected to compensate not only the costs of rent, insurance, and depreciation, but also an additional risk premium. Supply commences at *Z* if, on the contrary, the risk of grain storage is outweighed by its convenience.



Motes: Price of storage = Expected price increase – (rent + depreciation + interest). Y = Full storage.

Figure 1 *Two supply schedules for grain storage*

In England after 1400, the costs of rent, interest, and depreciation, have exceeded seasonal price variations. By implication, the supply schedule of grain storage has approximated *ZY* in Figure 1 during the early modern period, when

cliometricians have suggested the contrary. Why may they have been mistaken? The theoretical answer is contained in *Wealth of Nations*. Smith chose wheat as a constant measure for the value of labour.[38] In his day, as for centuries past, this partly reflected the high proportion of a labourer's budget spent on grain, partly the high proportion of labour still employed in agriculture, and partly the volatile nature of grain prices.

Were a peasant to sell his entire crop at harvest time for silver, then in Smithian terms the labour he could purchase at a future date would be of less certain value than the labour purchasable with wheat. Silver and money in pre-modern England may not have been equivalent. Money is three things: the best medium of exchange, the best unit of account, and the best short-term store of value.[39] Of these three attributes Smith claimed for silver only the first two; with wheat storing value better, at least in the short term. The monetary function of grain may have bestowed a 'convenience yield' on its storage. Such a monetary function has not disappeared with the advent of a global grain trade and futures markets. Indeed, Williams has recently argued that Kaldor's 'convenience yield' arose on grain and similar commodities traded in futures markets because "firms hold stocks of physical commodities for much the same reason they hold money."[40]

A test for the validity of this hypothesis to pre-modern times, is the behaviour of grain prices between harvest years. Samuelson argued that if supply and demand for grain were foreseeable, storage between harvest years would only occur after

[38] Smith, *Wealth of nations*, p. 33. Steuart, a contemporary political economist to Smith, advocated a formal monetisation of grain; with 'corn bills' circulating under the guarantee of grain bank: *Dissertation on the policy of grain*, pp. 11-4.
[39] On the roles of money, see Rosenstein-Rodan, 'Co-ordination', pp. 257-80; Einzig, *Primitiv money*, chapter 32.
[40] Williams, *The economic function of futures markets*, p. 39.

harvests so much better than average, that the price level in the succeeding year exceeded the inevitable costs of storing grain between times.[41] Had grain storage approximated *XY*, not *ZY* in Figure 1, then the additional cost of risk would decrease, rather than increase, the effect from storage of the price of grain this year on the price of grain next year. One method of classifying harvests and prices suggests that historically, the supply schedule of storage has been better approximated by *ZY*.[42] Prices, but not harvest yields, showed strong autocorrelation in successive years. Neilsen took this to imply profit-maximising storage. On closer examination, this appears to be only partial truth.

For the price in *year 1* to affect the price in *year 2*, the quantity of storage between the years must also have been sensitive to relative prices.[43] When the price in *Year 1* was lower than average, the price in *Year 2* would tend also to be lower than average, with substantial stocks from *Year 1* being carried into *Year 2*. In terms of Figure 1, whether the supply schedule of grain approached *XY* or *ZY*, this result would be expected: as the price of storage increased, so did its supply.

When prices were higher than average in *Year 1*, however, they also tended to be higher in *Year 2*; suggesting a diminution in supply to *Year 2* resulting from high prices in *Year 1*. Because grain was being stored between years when the price difference cannot on average have exceeded the inevitable costs of storage, the supply schedule *ZY*, not *XY*, is implied. These surmises are presented empirically in Table 4, which divides the annual wheat price by its fifteen-year moving average from 1260 to 1819.

[41] Samuelson, 'Towards a theory', pp. 188-90.
[42] Wrigley, 'Some reflections', pp. 264-78.
[43] Neilsen, 'Government', pp. 15-17.

Table 4 *The serial correlation of English wheat prices: 1260-1819*

(prices expressed in ratio to a fifteen year moving average)

Row	Price in Year 1	Price in Year 2				Price in Year 3			
		1260 -1399	1400 -1539	1540 -1679	1680 -1819	1260 -1399	1400 -1539	1540 -1679	1680 -1819
(1)	< 0.75	0.82	0.82	0.79	0.83	1.04	0.96	1.03	1.03
(2)	0.75-1.00	1.01	0.96	0.92	0.94	1.03	1.04	0.99	0.98
(3)	1.00-1.25	0.94	1.03	1.03	1.07	0.98	0.99	1.05	1.00
(4)	> 1.25	1.24	1.19	1.19	1.10	0.91	0.92	0.96	1.01

Note: For a discussion of this method, see Nielsen, 'Government', p. 15.

Sources: Bowden, 'Statistical appendix', pp.815-21; Bowden, 'Statistics'. Pp. 828-31; Farmer, 'Prices and wages' I-II, pp. 789-91 and pp. 502-5; Hoskins, 'Harvest fluctuations' I-II, pp. 44-6 and pp. 28-31.

When the price in *Year 1* was below 1.00 in ratio to the moving average (as in row (1) and (2)) it was on average below 1.00 in *Year 2*. This autocorrelation weakened only in the period 1260-1399. As columns 5 to 8 show, the autocorrelation was nullified between *Years 1* and *3*; suggesting the relationship between adjacent years did not result from longer cycles of harvest yields.[44] Had the supply schedule

[44] Evidence for longer cycles of 5-6 and 13-6 years has however been presented by Duncan, Duncan and Scott in 'The origins', pp. 1-14. Persson and Ejrnæs have argued that autocorrelation does not signify profit-maximiaing storage (as Nielsen claimed), and furthermore that price series for both storable and unstorable commodities show autocorrelation. This critique, however, neither rules out the price-effect of storable commodities on unstorable commodities, nor explains the elimination of autocorrelations over three years revealed by Table 4: 'Grain storage', pp. 1-15.

approximated *XY* in Figure 1, autocorrelation should only have obtained in rows *(1)* and *(2)* of the comparison with *Year 2*. The observable autocorrelation in rows *(3)* and *(4)* suggests it was better approximated by *ZY*.

IV

If the storage supply schedule of Figure 1 has apparently commenced at Z and not X since the fifteenth century, then why between 1260 and 1399 did seasonal price variations greatly exceed the costs of rent, depreciation, and interest? Risk, by implication, exceeded the convenience yield on grain storage as probably never since. And yet this century witnessed the worst recorded famines of English history. The production and consumption of grain, as sources of employment and sustenance, were then at their most significant. At that time, if ever, grain should have best stored the value of labour. The argument that pre-modern grain storage was influenced by the monetary function of grain, appears to fail exactly when its symptoms should most have been in evidence.

It is conceivable, nevertheless, that not only was the convenience yield greater than the risk of grain storage between 1260 and 1399, but also that seasonal price variations exceeded the costs of rent, interest, and depreciation. The additional assumption necessary to reconcile these two observations is that the grain economy of England during this period was underwritten by borrowing. Grain would be lent by creditors at the high cost in convenience of its foregone storage. The risk of default by their debtors on loans would then amplify the cost of credit in proportion to its convenience as a short term store of value.

The effect of loans, maturing after the following harvest, may have increased the cost of storing grain. Arbitrage could not negate this consequence. For when default is possible, the storage costs to borrowers of grain would include a risk premium additional to their accrued interest. While post-harvest repayments would not necessarily depress prices below their equilibrium level, outstanding loans would necessarily raise the subsequent cost of grain storage. In a sentence, the greater the convenience yield on holding grain stocks, the greater would be the risk premium on loaning grain, and the greater the cost of storing borrowed grain. Potentially, the additional cost of storing borrowed grain increased the seasonal variation of grain prices in England between 1260 and 1399.

The importance of credit in England during this period was denied by McCloskey and Nash, for the reason that high seasonal price variations reflected merely the high rate of interest.[45] But without measuring these costs independently, they could not exclude risk premia on loans from their number. Given the insufficient evidence of the extent of medieval credit, it is at least possible that Tawney was closer to the mark when he wrote: "In a world where seasons are uncertain and six months intervene between sowing and harvest, the need of advances was not the invention of man; it was inherent in the very nature of things."[46] Nineteenth-century Ireland is a yardstick by which the alternative views of Tawney and the cliometricians on medieval England can be judged. As Table 5 shows, seasonal price variations on potatoes and grains in pre-Famine Ireland were of comparable magnitude to those of England between 1260 and 1399.

[45] McCloskey and Nash, Çorn at interest', p. 185.
[46] Tawney, 'A discourse', p. 19; Fenoaltea has speculated along the same lines: 'Risk', p. 130. Clark states that insufficiënt direct evidence exists to reveal the extent of medieval rural credit. 'Debt litigation', p. 255.

Table 5 *Dublin wheat, oats, and potato seasonal price variations, 1799-1849*

Crop	Wheat	Oats	Potatoes
% increase from September/October to July/August	24.7	26.1	82.2

Source: Liam kennedy, Department of Economic and Social History, The Queen's University of Belfast

On the western Irish seaboard, poverty, monoculture, and price volatility dictated in one contemporary's words: "the barbarous custom of making the potato the labour coin of the country".[47] In this context, credit was by no means insignificant. Most respondents to the *Poor Inquiry* of 1836 stressed its importance in "periods of distress"; a regular occurrence between the exhaustion of one potato crop and the harvest of its successor.[48] Those of Kildonnel in Co. Galway for example stated: "labourers can obtain provisions on credit, but at a great sacrifice. It is their only resource."[49] Those of Galomy, Co. Kilkenny: "A greater or less number of labourers, according to seasons and circumstances, are every year compelled to resort to persons who give them either potatoes or meal on credit."[50] And those of Carbery, Co. Sligo: "As bad as trust (credit) is, the half of the people would die in the ditches if it were not for it."[51]

Tawney's conjecture of and economy underpinned by credit, seems closer to the mark than the cliometric deduction of a world in which credit was uncommon.

[47] Rogers, writing in 1847,quoted by Connell, *Population of Ireland*, p. 142.
[48] *Poor Inquiry*, pp. 1-37.
[49] *Ibid*., p. 2.
[50] *Ibid*., p. 10.
[51] *Ibid*., p. 7

Seasonal price variations in pre-Famine Ireland were as pronounced as medieval England's between 1260 and 1399, yet credit was almost certainly an essential insurance to farming labourers.

Seasonal price variations fell sharply in late nineteenth century Ireland, as they had in England 600 years before. Belfast potato prices varied 83.4 per cent seasonally between 1799 and 1849; while from 1850-99 they varied merely 21.7 per cent.[52] Credit remained important after the Famine in poorer districts. But the increase in both the value and diversity of farming incomes caused loan premia to fall more markedly still: as revealed by the comparison of short-term premia in Table 6 below between the *Poor Inquiry* of 1836 and the *Congested Districts Board* of 1898. The fall reflected not a drop in the base rate of interest, which hovered at between 2 and 4 per cent, but a diminution of the additional risk on loans.[53]

Table 6 *The cost of rural credit in nineteenth century Ireland*

(a) Poor inquiry (1836)

Province	Country	Barony	Premium (%)	'Hungry gap' (& loan period in brackets if specified)
Connaught	Galway	Kildonnel	60-80	1-3 months (until November)
	Galway	Kildonnel	100	1-3 months (until after harvest)
	Leitrim	Dromahair	67-100	1 month (4-5 months)
	Mayo	Murrisk	45-80	0-1 month
	Sligo	Carbery	100	½-2 months (until Christmas)
	Sligo	Carbery	60	½-2 months
Munster	Kerry	Iveragh	30-40	None
	Kerry	Trughenackmy	50	0-1 month
	Limerick	Conello	50	None
	Limerick	Coshlea	50	5 days

[52] Thanks to Liam Kennedy and Christopher McCormick for their data on belfast potato prices.
[53] 'O Brien, *Economic history of Ireland*, p. 543.

(b) Congested districts board (1898)

Province	Country	Barony	Premium (%)	Usual period of loan
Connaught	Galway	Letterfrack	10-20	6 months
	Galway	South Connemara	8	6-12 months
	Galway	Rosmuch	8	Idem
	Galway	Aran Islands	20-25	3-6 months
	Galway	Oughterard	4-13	3 months
	Galway	Glennamaddy	15-20	1 year
	Galway	Castlerea	20	Idem
	Leitrim	Kiltukbrid	20	1 year
	Mayo	Knockadoff	15-20	1 year
	Mayo	Belmullet	15+	1 year+
	Mayo	Ruthhill	15-20	1 year
	Mayo	Idem	10	3-4 months
	Mayo	Bangor Erris	10-15	<6 months
	Mayo	Ballycroy	15	9-10 months
	Mayo	Pontoon	19	3-4 months
	Mayo	Islundeady	10-20	6 months
	Mayo	Clare Island	10-15	6 months
	Mayo	Louisburgh	10-15	6-9 months
	Mayo	Aghagower	5-15	>3 months
Munster	Kerry	Listowel	5	1 year
	Kerry	Causeway	5	1 year
	Kerry	Waterville	8	3-6 months

Notes: Only Connaught and Munster were included for the purposes of comparison. The 'hungry gap' was included in *(a)* to indicate, albeit weakly, the length of loans.

Sources: *Poor Inquiry*, pp. 1-37; *Congested Districts Board*, pp. 16-713.

Changing seasonal price variations between pre- and post-Famine Ireland are thus more plausible accounted for by the significance and costliness of credit, than variations in the interest rate *per se*. When potatoes were the so-called "labour coin", the high convenience yield derived from their monetary function is also hard to doubt. To an even greater extent than in the late nineteenth-century Ireland, moreover, loan premia in England approximated the base rate of interest by the seventeenth century.[54]

[54] See Holderness, 'Credit', p. 97, and Muldrew, 'The economy of obligation', p. 114.

Is it then implausible to suppose that the high seasonal price variations in thirteenth- and fourteenth-century England reflected high loan premia, pervasive credit, and a high convenience yield on grain storage? Their subsequent fall would in consequence be attributable primarily to diminished credit risk, not the diminished rate of interest.

The significance of credit in pre-Famine Ireland, and the effect of a reduction to loan premia on the seasonal price variations of grain and potatoes thereafter, falls short of demonstrating the same developments in medieval England. The argument stand or falls on the strength of analogy alone. But had the same factors been operative, they might partly explain in both cases the substantial disparity between seasonal price increases and the storage costs of interest, rent and depreciation.

This explanation remains partial, however, because the high cost of holding inventories on credit need only have effected the average, but not the marginal cost of storage. Wealthy producers or merchants would not be affected by the additional cost of servicing loan interest. Why then, during the thirteenth and fourteenth centuries, were the seasonal variation of English grain prices not bid down by the competition of these more efficient stores?

Landed magnates could acquire grain for storage by any of several means. They could produce it directly, buy it on the spot market, or buy it on the forward market. All three opportunities were apparently available to them between 1260 and 1399. English latifundia of this period were described by Postan as " federated grain factories, producing mainly for cash."[55] Profitable grain production on such a large should have enabled landlords to acquire considerable inventories at low cost. Moreover, circa 1300 England had over 600 registered market places from where spot grain purchases could be made; a number not again matched until the late seventeenth

[55] Postan, 'The fifteenth century', p. 162.

century.[56] The lords of the land also held a natural advantage in the forward market for grain. In exchange for land and capital loans, a share of the following year's grain crop was theirs for the taking.

Despite the existence of these apparent opportunities for arbitrage, English seasonal price variations appear to have remained stubbornly high relative to the storage costs of rent, interest, and depreciation. By implication, the cost of acquiring grain for wealthy landlords or merchants was at least as great as the difference between the abovementioned costs and benefits of grain storage. So if wheat cost 19 per cent of its harvest time price to store, but rose in value by 33 per cent in storage, the additional cost of either producing it directly, buying it on the spot, or in exchange for a loan, must have been at least as high as 14 per cent of its harvest time price.

This hypothetical cost would sit oddly with t he view that English landlords were able to generate super-normal profits through the direct management of agriculture, and that the English grain market worked efficiently during this period. Yet an audit of the surviving accounts from English latifundia reveals that far from being money-spinners, these enterprises were awash with red ink. Some of the most intensive cultivated and productive land in western Europe was held by the Cathedral Priory of Norwich.[57] Circa 1300, they calculated the annual gains from their directly managed arable cultivation.[58] On such land, the return to the landlord would lie above one third and perhaps one half of the crop, if contemporary continental sharecropping is a fair comparison. But by their own account, the monks were received merely one

[56] Jones, 'Search costs', p.11.
[57] Campbell, 'Medieval agricultural progress', pp. 26-46.
[58] The *Proficuum maneriorum*: Norwich Record Office DCN 40/13. For the following account of land management in medieval England, see Poynder, 'Landlords and the grain market in medieval England', Chapter 5.

quarter of the crop in return for their investment. By implication they were throwing away one quarter of the harvest-time value of a one-third share of the crop.

Perhaps direct management persisted, nonetheless, because its chief function was not a high return, but instead greater liquidity. Since grain prices rose seasonally, grain locked in the barn stored value better than silver locked in the treasure chest. In the absence of an efficient banking system, landlords may have played bankers to themselves through the production of grain. The scale of latifundia would therefore be limited by the demand of landlords for cash balances. As a consequence, when in the fifteenth century seasonal price variation became more muted and grain no longer stored value better than silver, landlords generally abandoned their direct management of agriculture.

Purchasing grain, either spot or forward, may have been no less costly than its large-scale production. While grain probably cost less to produce on peasant farms than on latifundia, landlords or merchants had, nevertheless, to purchase that grain for storage. In the thirteenth and fourteenth century, English landlords rarely bought grain on either the spot or forward markets.[59] To avoid buying grain on the spot market, they conveyed it great distances from their arable latifundia.[60] When direct

[59] 86 per cent of the grain consumed by nine English monasteries between 1250 and 1399 was not bought on the spot market. On eight estates, of the grain not bought on the spot market, 85 per cent was drawn from directly managed arable land.

[60] Wheat, barley and oats were transported on average around twice the distance on 11 monastic estates, than they were transported to market places adjacent to these monasteries.

agricultural management of agriculture was strong, rents in grain were likewise rare from the two-thirds of arable land that remained in tenant hands.[61]

Could the costs of either searching for grain in the open market, or enforcing grain rents, been high enough to account for both the extensive latifundia, and the high seasonal price variations, of thirteenth- and fourteenth-century England? The inefficient large-scale production of grain for cash balances would be unnecessary if the same grain could be purchased costlessly from more efficient producers. The cost of searching out grain from small-scale producers had probably been high for landlords and merchants throughout the medieval period. Thus the English crown, when in need of grain, would purchase wholesale supplies from latifundia, in preference to the peasant retail market.[62] Rents received in grain might also have presented landlords with a higher risk of default than rents received as silver, since both their quality and their quantity could be stinted. Landlords were highly sensitive to the quality of grain, as was shown in 1515, when the monks of Ely complained that their barley ale was *ita debilis quod porci ex ea non libenter biberent* (so disgusting that even the pigs would not freely drink it).[63] The widespread poverty suggested by contemporary seasonal price variations, may explain why monitoring such quantitative variations remained prohibitively costly during the period 1260-1399.

[61] In the 1279 *Hundred Rolls*, villein tenant rents in the south and midlands of England, by value perhaps 80 per cent of all tenant rents, were overwhelmingly collected in silver: Kominsky, *The agrarian history of England*, p. 154.
[62] In 1319, only nine per cent of the 7,893 quarters were bought by royal agents from the market, and not direct from latifundia. For references, see note 30 above.
[63] Evans, *Ely chapter*, p. 67.

With the market decline of seasonal price variations in fifteenth-century England, direct agricultural management was widely abandoned, and landlords supplied their households with grain purchased principally on the forward market. By implication, the difference between the seasonal price variation of grain and the storage cost of rent, interest, and depreciation between 1260 and 1399, resulted from a double bind. Small-scale producers faced the additional storage cost of an expensive credit market, while non-borrowers had either to produce grain on a large scale inefficiently, or pay the high transaction costs of the spot and forward grain markets. In England, moreover, the chronology of landlord estate management suggests that the declining transaction cost of forward purchase was key to the dramatic fall in seasonal grain price variations after 1400.

V

Analogy is not only a means for understanding the seasonal variations of grain prices in medieval England. Institutional change within medieval England might also shed light on the seasonal variation of grain prices in other times and places.

Can the high costs of both the large-scale production and the purchase of grain be ascertained in pre-Famine Ireland? Unlike thirteenth- and fourteenth-century English landlords, Anglo-Irish landlords did not create latifundia. Instead they fragmented their estates through leases. Perhaps the existence of efficient banking fascilities obviated the need for direct management in pre-Famine Ireland?[64] The

[64] Vaughan, *Landlords and tenants*, pp. 130-7.

demand for labour services, and the rarity of rents in grain do, however, point to similarities in terms of land tenure between pre-Famine Ireland, and England c. 1260-1399.

The search for analogies can also be extended to modern developing economies. Late twentieth-century seasonal price variations for staple crops appear also to exceed their storage costs in regions of India, Nigeria and Tanzania.[65] Might the same explanation apply? Like cliometricians, development economists have largely accounted for this disparity by adding a risk premium to the cost of holding grain stores.[66] The logical difficulties with this explanation, apparent in the history of pre-industrial Europe, also apply in these contexts.

The latifundia of medieval England may also find parallels in the serf-run estates of eastern Europe during the early modern period. Kula argued that the latifundia of sixteenth- and seventeenth-century Poland ran at a severe loss in conventional terms.[67] Polish landlords were, moreover, like their English counterparts, largely self-sufficient at this time.[68] Storage of grain on several Polish latifundia also appears to have cost less than the concurrent seasonal variation in grain prices.[69]

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[65] Ashimogo, in *Peasnant grain storage*, concluded that: "the net seasonal rice in prices [of maize] exceeds the expected price rise resulting from storage costs", p. 256. Similarly, Hays and McCoy, 'Foodgrain utility in northern Nigeria', p. 189; and Lele, *Foodgrain marketing in India*, p. 141.
[66] Hays and McCoy, 'Foodgrain utility in northern Nigeria', p. 189; Lele, *Foodgrain marketing in India*, p. 26 and p. 147; Sahn, 'The nature and implications for market intervention', p. 187.
[67] Kula, *Economic theory of the feudal system*, pp. 35-6.
[68] *Ibid*., pp. 141-2.
[69] Majewsky, *Gospodarstwo folwarczne*, p. 237. Thanks to Dr. Richard Butterwick, Department of History, Queen's University Belfast, for the translation.

The slave-run latifundia of the New World, on the other hand, present a contrast with both medieval England and early modern Poland. These ran at a profit when compared with alternative form of investment.[70] The plantation owner's easy access to banks would have made anything but a handsome profit from slavery wasteful.[71] Where large-scale agricultural production was profitable, it would be expected that seasonal price variations did not exceed the cost of storage in rent, depreciation, and interest.

Thus medieval English history suggests that, when applied to agricultural markets of the past, cliometricians have neglected the institutional constraints on the acquisition of grain. The result has been an impoverished theory of storage. "Historical economics", McCloskey wrote, "applies the theory to history almost invariably in the service of history, not in the service of economics."[72] Isn't it now time to recognise that the service must be returned; for the sake of a truly economic history?

[70] Fogel and Engerman, *Time on the cross*, I, pp. 68-71, and p. 245; Van Young, *Hacienda and market*, p. 224.
[71] Rothstein, in 'The cotton frontier', pp. 163-4, describes how even the pioneers of cotton production were able to draw on strong mercantile credit links.
[72] McCloskey, *Econometric history*, p. 14.

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