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ABSTRACT

Medieval bishops condemned and restricted the sale of corrodies (a type of annuity), partly on the grounds of their perceived unprofitability. The available data on the profitability of corrodies is limited and little analysed, and the episcopal condemnation of corrodies has been adopted by modern researchers. After recognising the difficulties, this paper applies an annuity pricing model to study corrody pricing. Given various assumptions, contrary to the established view, it is argued that the sale of corrodies was financially profitable for institutions. Finally, some reasons are considered for the negative attitude of contemporary and historical opinion towards the sale of corrodies.

Key words: Corrodies, pensions, annuities, monasteries, pricing models.

1 Introduction

There is an extensive literature on the provision of corrodies, a form of pension, by medieval religious institutions in England. This paper is the first to explore the pricing of corrodies using actuarial techniques, and sets out to challenge the prevailing view that monasteries sold corrodies at uneconomic prices. It finds evidence supporting the view that, if anything, corrodies were sold at a profit.

This finding is consistent with the many examples in financial economics of prices being set more or less in accordance with undiscovered pricing models; for instance option prices reflected the Black-Scholes option pricing model well before it was published (Black and Scholes, 1972; Moore and Jun, 2006). Looking for further historical evidence, it has been shown that over the period 1723-1794 prices on the London and Amsterdam stock markets moved in accordance with the weak form of the efficient markets hypothesis proposed by Fama (Neil, 1990; Fama, 1965). Similarly, between 1771 and 1777 the prices in Amsterdam of three English stocks moved in response to the arrival of news, consistent with weak form efficiency (Koudijs, 2009). For 1728-1761 it has been demonstrated that yields on bonds issued by the East India Company correctly reflected the put and call options embedded in these bonds (Marco and Malle-Sabouret, 2007). From a medieval perspective, it has been demonstrated that advance contracts in wool from the thirteenth century were priced in accordance with the valuation formula developed in the last few decades to price forwards contracts (Bell, Brooks and Moore, 2009). Furthermore, it is argued that the behaviour of medieval lenders matches the predictions of rational behaviour given by a theoretical model of debt markets incorporating the ban on usury (Koyama, 2008). In addition, it has also been found that modern microstructure models of volatility clustering for both prices and bid-ask spreads applied in early renaissance Florence (Booth and Gurun, 2008). The analysis of corrody pricing in this paper presents additional evidence in favour of the rationality of medieval price setters, supporting the application of modern pricing models to medieval problems (Nau and Schefold, 2002).

Under a corrody, an individual or couple was provided by a religious institution such as a monastery, priory, abbey or hospital with some agreed mixture of food, drink, heat, light, accommodation, clothing, laundry, health care, maybe a small monetary allowance and even stabling and grazing for their livestock (Williams, 1983, pp. 288-294).[1] Initially the word corrody referred to food and lodging supplied by vassals to the lord on his circuit, and the first usage of the word in the sense it is used in this paper was in 1197 (Wilson and Jones, 1917, p. 5). Each corrody was negotiated and recorded, and the terms differed between deals, although there tended to be accepted grades of corrody (Harvey, 1993, pp. 181-184; Keil, 1963-64, pp. 113-114; Cullum, 1991, p. 9). For purchased corrodies the value of the goods

[1] Some corrodians were granted the use of a garden (Little, 1958, p. 12).

and services supplied varied with the purchase price.[2]

Since it involved the supply of a specified quantity of goods and services for the life of the corrodian, a corrody can be compared to a life annuity. Equating corrodies with life annuities is common practice throughout the existing literature, and the equivalence is maintained in this paper. The church sold annuities from the eighth century onwards, and by the fourteenth century the sale of annuities was an established activity (Jack, 1912, pp. 170, 174). There was no hard and fast dividing line between corrodies and pensions (annuities); as corrodies could turn into pensions when the benefit was provided in cash, not in goods and services (Cook, 1961, p. 21; Keil, 1963-64, p. 116; Snape, 1926, p. 139; Thompson, 1928, p. 117; 1947, p. 175; Tillotson, 1974, p. 133; Williams, 1983, pp. 78, 86-87). The institutions probably possessed significant economies of scale in the provision of food and shelter, for instance cooking communal meals. Therefore the marginal cost to the institution of providing the goods and services comprising a corrody was less than if the institution had provided the corrodian with sufficient money to purchase these items themselves. Because a corrody usually involved the supply of goods and services, rather than cash, it was effectively inflation proof.

There were, of course, other methods of providing for old age in medieval times. For example, the family could provide its own form of longevity insurance. Using a theoretical model with assumed parameters, Kotlikoff and Spivak (1981) demonstrate that families of just three people can provide over 70% of the benefits of fairly priced annuities. Under this model, parents promise to leave all their assets to their child, in return for their child agreeing to support them until their death. They calculate that this would give the parents 71% of the gain from a fair annuity contract, while the child would gain 45% of the benefits that would have been available to them from using annuities. Using historical examples, Clark describes how in medieval times the elderly entered into agreements with their children (or others) under which they worked their parents' land and supported them until their death in return for inheriting the land. Such arrangements had the advantage that the pensioners did not have to relocate from their familiar surroundings (Clark, 1982; 1990).[3] One further alternative to buying a corrody was for people to sell their land for a cash sum, which was paid in installments over a number of years (i.e. an annuity certain), or for the life of the vendor, i.e. a level life annuity (Clarke, 1982; 1990). The existence of these alternatives to corrodies means that, not only would institutions have competed with each other when pricing these products, but also with these close substitutes.

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[2] There were other types of corrody, such as those awarded by the King or the patron of the institution for service, by the institution to its servants, and in exchange for a transfer of property. The analysis in this paper concentrates on cash sales (Tillotson, 1974, p. 131; Snape, 1926, pp. 139-143).

[3] These retirement contracts have also been described by Thane (2000, pp. 75-81), Jack (1912, pp. 177- 179) and Smith (1991).

Institutions had a number of different demands on their established income, including building works, taxation from the Crown and the Papacy, their duty to look after pilgrims and the poor and also the possibility that the King may call on them and stay for a while, at their expense. They could have taken the easy way out of their cash flow problems and sold some of their substantial land holdings. However, the liquidation of real estate assets was frowned upon, and certainly not widespread practice. The sale of land, and even the alienation of property, was seldom undertaken as it was not regarded as good practice, or even in the long-term interests of the institution. Therefore this course of action would only be taken in extreme circumstances, such as impending bankruptcy. Even in such cases, permission for land transactions had to be granted by the ruling authority of the religious order, and they were not keen to encourage these practices.[4] Harvey (1993, p. 120) shows how Westminster Abbey actively pursued a policy of expanding its landholding, and attempted to regain land that had previously been lost due to the "principle mistakes of their twelfth century predecessors".

It has been argued by historians that the late thirteenth and early fourteenth century was a time of great hardship for landowners following a series of famines affecting crop production, and murrain amongst livestock, leading to dispersal for some institutions that fell into bankruptcy (Campbell, 1991; Kershaw, 1973b). Bell, Brooks and Dryburgh (2006) have shown that some Cistercian houses, such as Pipewell in Northamptonshire, tried to use forward contracts in wool to alleviate their cash-flow problems, while Jordan (1996, pp. 65-67) has demonstrated that other European houses relied on the sale or alienation of their real estate portfolios to avoid the fate of dispersal during this period of economic difficulty. The sale of corrodies fitted into this emerging pattern of such institutions finding increasingly sophisticated methods of generating ready cash to enable them to continue to function effectively.

Section 2 summarises the view of modern researchers and medieval bishops that the sale of corrodies damaged the finances of institutions. Section 3 sets out a model for pricing annuities, and section 4 considers the applicability of this model to corrodies. Section 5 discusses some difficulties in determining whether corrodies were fairly priced, while section 6 contains an analysis of the effect of selling a corrody on the cash flows of the institution. Section 7 presents an empirical analysis of corrody pricing based on two separate samples. Finally, section 8 has the conclusions which reconcile the negative views of corrodies with the practice of overpricing.

2 Contemporary and Historical Perceptions

This paper focuses on corrodies purchased using either cash or land, and considers whether these sales were financially harmful to the supplying institution. Much of the previous literature on purchased

[4] Jordan (1996, p. 69) describes a couple of examples from religious institutions within the Holy Roman Empire.

corrodies has questioned whether the institutions benefitted from selling corrodies, and most previous researchers have concluded that corrodies were financially damaging to institutions. Some examples of the views of researchers will be given, followed by the contemporary views of medieval bishops. Previous researchers did not conduct an economic analysis of corrodies, and appear to have based their negative views on corrodies being sold to meet immediate cash needs, their condemnation by the bishops, and the exposure to longevity risk.

In his study of Bolton Priory, Kershaw (1973a, pp. 135-6) concludes that there was a clear positive connection between the sale of corrodies and financial difficulties for this institution; although he also estimates that between 1320-1325 the priory had to pay out approximately 6.5% of their total outgoings on servicing corrodians, which he describes as "a not unmanageable proportion". Bottomley (2002, pp. 114, 162) thinks that corrodians increased the financial problems of St Leonard's Hospital York, while St Nicholas Richmond suffered financial problems from the imprudent grant of corrodies. At the friary at Bishop's Lynn and at Selby the sale of corrodies drained their resources and undermined their finances (Swanson, 1993, p. 236). The sale of corrodies also burdened St Albans (Moorman, 1945, p. 271).

Cullum (1991) states that the actuarial calculations of the masters of St Leonard's Hospital York were inadequate, and the corrodians were more expensive to support than provided for in the initial charge. She concludes that the master of St Leonard's Hospital York sold corrodies and liveries at a great rate, which burdened the hospital, and in 1399 it defaulted on some corrodies and liveries.[5] As corrodies were sold, an increasing proportion of the hospital's income had to be spent on their servicing. This created a vicious circle in which more corrodies were sold to generate cash to service previous corrodies (Cullum, 1991, pp. 6, 9. 28; Swanson, 1993, p. 237).

More generally, Dyson et al (1969, p. 2) conclude that corrodies were a bad bargain for the monasteries, while Thompson (1947, p. 174) accepts that corrodies "corroded and gnawed on monastery finances". He states that the sale of corrodies led to serious difficulties, was a financially unsound policy and proved a dead loss to the monasteries, providing no adequate return (Thompson, 1914, p. 229) and that the sale of corrodies "brought ...... debt and difficulty" to institutions (Thompson, 1921, p. 258). Hunt (1893, p. xxiii) thinks that sales of corrodies "may well have been prejudicial to the interests of the community, and when a convent was in pecuniary difficulties it is easy to believe that the monks must have sometimes made a bad bargain in order to relieve themselves of instant pressure"; and "the sale of corrodies was by no means to be commended". Coulton (1936, p. 540) concludes that the evidence is

[5] Liveries in this context were minor corrodies.

overwhelming against the view that some corrodies were good business bargains. Snape (1926, pp. 144-5) reports frequent records of the burden placed on monasteries by the sale of corrodies. He concludes that, since German towns in the thirteenth century sold life annuities at a loss, it is hardly likely that the monks had any greater success selling corrodies. Harper (1983, p. 96) writes that "fifteenth century corrodies ... are regarded by modern historians as a grievously unsound policy." He accepts that selling corrodies may have been a burden on monasteries, but argues that giving corrodies to faithful servants, the sick, and the poor and feeble was a sound and laudable practice. Kitchin (1892, p. 25) refers to corrodies as "this most unthrifty kind of loan", whilst Baskerville (1937, p. 66) comments that "many abbeys were crippled financially by the reckless granting of corrodies".

These negative opinions on selling corrodies by academic researchers are similar to the contemporary judgements of medieval bishops who consistently condemned and criticised the sale of corrodies (Harper, 1983, p. 96; Keil, 1963-64, p. 115; Kershaw, 1973a, p. 135; Moorman, 1945, p. 271; Swanson, 1993, p. 236; Thane, 2000, p. 83). In some cases the permission of the Bishop was required before a corrody could be granted (Little, 1958, p. 14; Snape, 1926, p. 145; Thompson, 1947, p. 175).[6] In 1442 the Prior of Canons Ashby Priory informed the bishop that "the house has come to ruin by the sale of the corrody and of the copses"(Thompson, 1918, p. 45). At St. Frideswide's Priory Oxford the bishop predicted that, as a result of their sale of corrodies, the priory would be "cast down into the well of destitution" (Thompson, 1918, p. 100).

In 1385, after visiting Southwick Priory, William of Wykeham, Bishop of Winchester, informed the prior that abbeys and priories who have sold corrodies are "burdened with such sales and grants, the numbers unduly diminished of those for whose sustentation the said possessions have been specifically assigned by the founders thereof and by other faithful Christians, and those abbeys and priories are defrauded of their due services and have suffered grievous evils to the peril of the [founders' and benefactors'] souls and to the grievous prejudice and manifest scandal of the said abbeys and priories" (Coulton, 1936, p. 242). In about 1200 at Cirencester Abbey the Archbishop of Canterbury and Bishop of Worcester decided that "no other corrodies are to be sold, for sale savours of simony" (Cheney and John, 1986, p. 77). In 1268 the papal legate Ottobuono (subsequently Pope Adrian V) decreed that by

[6] Reports of the visitations reveal a ban on the sale of corrodies without the express permission of the bishop of Lincoln at Bardney Abbey, St. Leonard's Hospital Bedford, Brackley Hospital, Burnham Priory, Caldwell Priory, Canons Ashby Priory, Croyland Monastery, Daventry Priory, Dorchester Abbey, Dunstable Priory, Elstow Monastery, Eynsham Monastery, Humberstone Abbey, Huntingdon Priory, Kyme Priory, Laund Priory, Leicester Abbey, Markby Priory, Missenden Monastery, St. Frideswide's Priory Oxford, Peterborough Monastery, St. Neot's Priory, Stonely Priory, Thornholm Priory, Thornton Monastery and Wellow Abbey (Thompson, 1914, 1918 and 1929).

selling corrodies "the churches are defrauded of due service, and the poor and sick are cheated of their sustenance" and those who sold corrodies would be excommunicated (Coulton, 1936, p. 245). Thompson (1928, p. 119) suggests that some of this episcopal censure was because selling corrodies resulted in lodgers who had nothing to do with the religious purpose of the institution. However, he goes on to conclude that the main reason for their condemnation was that corrodies were a financial burden, and led to financial weakness for institutions.

Therefore, both historians and contemporary opinion have concluded that the selling of corrodies was not a financially profitable business for religious institutions.

3 A Model for Pricing Corrodies

Actuarial pricing formulae will now be used to investigate whether these negative conclusions are justified. As discussed, corrodies were essentially life annuities. Therefore, the appropriate model for pricing corrodies is that for pricing single premium, inflation-proofed, immediate, life annuities. A simple pricing model which gives the actuarially fair price of an immediate, inflation-proofed annuity on a single life is:

$$V_{xA} = \sum_{i=1}^{n} \frac{A.P_{xi}}{(1+r)^i} \qquad (1)$$

where V_{xA} is the current price of the annuity, i is the number of years since the annuity was purchased, r is the real rate of interest, A is the annual payment under the annuity (fixed in real terms), n is a number greater than the remaining years of life of the corrodian, and P_{xi} is the probability that an annuitant aged x when the annuity was purchased survives for at least i years. The real rather than the nominal interest rate is used as the discount rate because most of the benefits of a corrody were provided as goods and services, not cash, and so were expressed in real terms.[7] Models for pricing annuities or corrodies on the lives of a couple are more complicated.[8]

Corrodies are usually priced by historians in terms of "years purchase" i.e. (Price/Annual Payment), with no adjustment for the time value of money or the probability of survival. Years purchase is the

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[7] Equation (1) assumes the yield curve is flat, but in reality this may not be the case. If a single interest rate is used to discount the cash flows, this rate needs to be roughly in the middle between the highest and lowest rates expected over the life of the corrody.

[8] Pricing annuities on joint lives involves some additional factors - the specified fraction of the initial annuity received by the survivor; whether it is a last survivor or a contingent survivor annuity (see section 8), and the degree of correlation between the life expectancy distributions of the two annuitants (Brown and Poterba, 2000).

undiscounted payback period.[9] Some authors state the price of a corrody in terms of a rate of interest computed as the reciprocal of years purchase, expressed as a percentage.[10]

Sometimes perpetual corrodies (i.e. when the corrodian dies, the corrody passes to someone else, and so on) were sold, and a simple pricing model which gives the actuarially fair price of an immediate, inflation-proofed, perpetuity (V_p) is:

$$V_p = \frac{A}{r} \tag{2}$$

where r is assumed constant over time. In this case survival probabilities are not required; nor is any information on age at purchase needed. For any life annuity or corrody, the value given by equation (1) cannot exceed that for the equivalent perpetuity given by equation (2); giving an upper bound on the price that should be charged for any non-perpetual corrody.

4 Applicability of the Annuity Model to Corrodies

This paper compares the actual prices actually set by medieval institutions with the actuarially fair prices. The applicability of the modern annuity pricing model in equation (1) to medieval corrodies will now be considered under three headings - the requisite theoretical knowledge, the required empirical knowledge, and the assumptions underlying the annuity pricing model. To the extent that institutions lacked the intuition to set corrody prices close to those given by equation (1), they may have tended to over or under price corrodies.

Theoretical Knowledge. The annuity valuation model makes use of the concepts of probability and discounting, which were unknown in medieval times. Therefore the suppliers of corrodies could not have conducted modern computations to set the price of a corrody. However, it is reasonable to expect that medieval institutions took some account of the time value of money and the probability of death when setting the price of corrodies, even though they had no knowledge of equation (1).

Empirical Knowledge. A key input to equation (1) is the probability of survival for at least i years, and this requires a knowledge of mortality tables. We will now consider how mortality tables need to allow for adverse selection, and how the inputs to equation (1) are subject to estimation risk.

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[9] There is a substantial literature on the use of the payback period as an investment appraisal technique, which concludes that it is not a suitable method for measuring the attractiveness of an investment (Brealey, Myers and Allen, 2006, p. 90).

[10] For example, if the corrody pays £10 per year and costs £100, its years purchase is 100/10 = 10 years, corresponding to an interest rate of 10/100 = 10%.

The annuity pricing model requires access to accurate mortality tables for the computation of the probability of survival to year *i*. The earliest recorded life annuities were sold by the Greek city state of Miletus in 205 BC, where the initial price was set at ten times the annual payment, without any access to a mortality table (Homer, 1977, pp. 37-38). The word annuity comes from the Latin *annus,* and the first age-related method for valuing annuities was used by the Romans. From 40 BC Romans were required to leave at least a quarter of their estate to their legal heir. If they had left life annuities (or the use of an asset for life) to others, these were valued using a method which relied on the age of the beneficiary in a very crude way. In about 220 AD Domitius Ulpianus proposed a superior method for valuing such annuities which relied on age in a more sophisticated manner (Greenwood, 1940; James, 1947, pp. 6-7; Mommsen, Krueger and Watson, 1985, 35:2:68; O'Donnell, 1936, pp. 109-112; Poitras, 2006, pp. 80-81). In 1653 Lorenzo Tonti was the first person to publish a mortality table, but this is not thought to have been based on real world data (Hald, 1990, p. 120). In 1662 John Graunt published the first mortality table based on actual data (for London) (Hald, 1990, p. 120; Daston, 1987, pp. 240-241). Therefore, no mortality tables based on real world data were available to those setting the price of corrodies.[11]

As the Roman example proves, even in the absence of data-based mortality tables, age can be allowed for when pricing annuities. It is common sense that young people tend to live longer than old people, and so some approximate adjustment (honed by experience) can be made to annuity and corrody prices. For example, annuity prices varied with age in Hanover in 1350, Augsburg in 1373 and Breslau in 1342-1379 (Jack, 1912, p. 175).

There is a tendency for those who subsequently have lives of above average length to buy annuities. This is probably due to their detailed knowledge of their own health and lifestyle and those of their close relatives. Since those who actually buy annuities have a greater life expectancy than the general population, the suppliers of annuities must increase the price of their product to protect themselves against such adverse selection. This price increase makes annuities unattractive to the average person. In addition, it is possible another factor was at work to ensure that corrodians lived longer than average. Relative to the general population, monks were very well fed, clothed and sheltered; and had excellent sanitation, hygiene and medical care (Hatcher, 1986, p. 33). Since corrodians shared the life of monks, it is possible that this increased the life expectancy of corrodians, further increasing the adverse selection.

[11] Shahar (1993) concludes that in medieval times the low life expectancy at birth was primarily due to high infant mortality, those who became adults had a good chance of surviving to be 60 or 70 years old, and old age did not set in until a person was aged 60 or 70. Retrospective studies of mortality in medieval times indicate that monks and peers had life expectancies which were not too different from those of modern times (Rosenthal, 1973; Hatcher, 1986).

While modern studies find monks and nuns have a substantially greater life expectancy than the general population, in medieval times Hatcher et al (2006, p. 683; also Flannelly et al, 2002) conclude that monks and nuns had a lower life expectancy than the population. This is attributed to their communal living, contact with dense urban communities, an unbalanced and excessively rich diet, and a lack of exercise. Poorer life expectancy may have reversed any adverse selection, reducing the fair price of a corrody.

Adverse selection is facilitated by a lack of compulsion to buy an annuity, and by a small market for annuities, and both of these factors applied to corrodies. However, the residential nature of corrodies prevented the very young from becoming corrodians, and tended to attract the elderly. This limited adverse selection, although Harvey reports that some corrodies were purchased by young adults (Harvey, 1993, p. 208). The observation by Cullum (1991, p. 25) that corrodies were priced at about ten years purchase is consistent with sensible age-independent pricing when substantial adverse selection by age is not important. While no researcher has produced evidence that the prices of corrodies varied with the age of the corrodian, there may well have been some crude adjustments to allow for differences in age. Such a study would require data on the age of corrodians when they entered into the deal, or their estimated life expectancy at the time of the transaction. Some corrodies were transferred or resold and this suggests that the identity (and age) of the corrodian was not of major concern to the supplying institution (Harvey, 1993, p. 187; Lewin, 2003, p. 41; Snape, 1926, p. 139; Thompson, 1928, p. 121; Tillotson, 1974, p. 133; Williams, 1983, p. 79; Wilson and Jones, 1917, p. 6 and p. 7).[12]

As well as longevity risk, institutions supplying corrodies also faced estimation risk - they did not know the value of the inputs to the annuity pricing model for certain, for instance the future cost of providing the goods and services required under the corrody, the current age of the corrodian, the survival probabilities for someone of the corrodian's age, and real interest rates in future years. This estimation risk should have led institutions to charge a higher price for their corrodies.

Assumptions. The simple annuity pricing model in equation (1) makes a number of assumptions which may not have been met.[13] Equation (1) uses the time value of money to compute the present value of a corrody, and the general theoretical validity of this approach requires perfect capital markets

[12] If a corrodian had the right to resell the corrody, this would have decreased its initial attractiveness to the selling institution, and increased its attractiveness to the purchaser. Such a corrody would be described in modern financial parlance as containing an embedded option.

[13] Friedman (1953, pp. 3-46) has argued that models should be judged by their ability to aid understanding and make predictions, and not by the validity of their assumptions.

(Hirshleifer, 1958). This was not the case in medieval times, and it is debatable whether it is true now.[14] In the absence of perfect capital markets the use of present values is problematic and the time preferences of the parties, which are unknown, become relevant.[15] The validity of this pricing model depends on the existence of competition in the corrody market, with rival suppliers of corrodies, such as other institutions selling corrodies, and the availability of close substitutes for corrodies, for instance retirement contracts. While there were rival suppliers and close substitutes, since each corrody was unique, the degree of competition that existed is questionable.

It is assumed that the real rate of interest (r) at which the supplier of the corrody invested the proceeds of the sale is known for the life of the corrody. Whether the riskless rate or some higher rate is used as the discount rate in equation (1) depends on the certainty with which the annuity or corrody payments will be made (Poterba, 2001, 568) and the rate at which an institution can borrow is usually a suitable discount rate. The certainty with which the payments will be made partly depends on whether the supplier can invest the sale proceeds in a way which hedges the risks inherent in the annuity or corrody.

Selling annuities involves the risk of unexpected changes in aggregate longevity. There was also exposure to unexpected changes in real interest rates, with no medieval financial instruments available for hedging this risk, nor for hedging longevity risk. Therefore, the institutions selling corrodies could not hedge all the risks involved, and this will have reduced the attractions of such business to institutions. The continued existence of the institution supplying the corrody was a vital consideration for potential corrodians as the corrodian was accepting the risk that the corrody would not be honoured (Cullum, 1991, p. 30). In some cases institutions sold a corrody, but then obtained the permission of the King to repudiate the corrody (Haren, 2000, p. 121; Wilson and Jones, 1917, p. 7; Wood-Legh, 1934, pp. 27-8, p. 56). This possibility increased the risk of non-performance for corrodians, reducing the price they were prepared to pay for a corrody.

The model assumes the average mortality experienced on the annuities or corrodies an institution has sold corresponds to the mortality table used in equation (1), which will only be true if a large sample of

[14] For instance, the problems experienced by Northern Rock plc in September 2007 were due to its inability to borrow in the financial markets, despite being able to offer good collateral.

[15] If the monastery invests the proceeds to generate money to service the corrody and consumes any surplus or loss when the corrody ends, the lending rate is the appropriate discount rate. If the monastery uses the sale proceeds to pay off outstanding loans to the monastery and consumes the surplus or loss on the corrody now, the borrowing rate is appropriate. For other patterns of borrowing, lending and consumption, a mixture of borrowing and lending rates is required. If there are perfect capital markets and the borrowing and lending rates are the same, this potential complication disappears.

lives is involved. Therefore institutions needed to sell a substantial number of corrodies for the longevity risk specific to each individual nominee (the person on whose life the annuity was based) to be diversified away.[16] Since each institution had only a few purchased corrodies outstanding at any one time, the longevity risk specific to each corrodian was only partially diversified away. In consequence, the attractiveness of trading corrodies was greatly reduced as the institution did not diversify away all of the specific longevity risk.

The annuity model does not incorporate any allowance for administrative costs, marketing expenses and risk aversion by the supplier. Brown and Warshawsky (2004, p. 337) suggest that allowance for these costs might add 3-5% to the price of a modern annuity. While medieval institutions did not market their corrodies, they must have incurred costs in administering corrodies. Unlike today's insurance companies, medieval institutions would not have had the benefit of substantial economies of scale from administering tens of thousands of corrodies. They also had to administer the daily supply of goods and services, rather than a monthly money transfer, reducing the attractiveness of selling corrodies. In addition to the undiversified specific longevity risk mentioned above, the suppliers of corrodies also assumed cohort longevity risk.[17] Equation (1) assumes that any cohort-wide improvements in longevity have been correctly incorporated into the mortality tables. For example, longevity may have been on a long term upward trend, while a major plague or famine could substantially lower the average longevity of a particular cohort of corrodians. This risk would have further reduced the attractiveness of selling corrodies.

Equation (1) also assumes that the institution receives all the proceeds from the sale of a corrody. However, the corrupt master of an institution could sell corrodies to augment his own stipend (Bottomley, 2002, p. 84). The prior of the Cathedral Church at Bath was alleged to have taken some of the money from the sale of a corrody for his own use (Lewin, 2003, p. 27) and three of the masters of St Leonard's Hospital York were accused by the local community of stealing most of the money received from selling corrodies (Cullum, 1991, p. 27). Snape (1926, p. 144) reports that the abbot of St Albans received £1,077 from the sale of corrodies which he spent on himself, while the abbot of Peterborough Abbey was accused of giving the receipts from selling corrodies to his brother (Thompson, 1918, p. 275). Corrupt masters may have sold corrodies at uneconomic prices because they anticipated personal

[16] Specific longevity risk is the risk that the date of death of a particular corrodian differs from the average date of death for that age cohort of corrodians.

[17] For example, the risk that the average date of death for an age cohort of corrodians differs from that predicted by the mortality tables.

gain.[18] The rolls of parliament of 1318 report an interesting case regarding the potential for the fraudulent exploitation of corrodies by a third party. In 1307 the Hospital of St Thomas of London was in the custody of the master and brethren of Ashridge College.[19] However, by 1315 the hospital had been surrendered after the college was accused of having 'alienated various tenements and burdened the house with corrodies and other things of that kind'.[20] The implication is that Ashridge College took the cash associated with the sales of the corrodies, and left the hospital with the problem of servicing these corrodies.

Equation (1) assumes a single mortality table. Hatcher et al (2006, figure 4, p. 677) shows the crude death rates for three English monasteries over the period 1395-1529. While there is considerable variation from year to year, the moving average is remarkably stable at about 30 deaths per thousand, with no long term trend. Therefore, if the prices of corrodies were based on past experience, expected mortality would also have been fairly constant and not varied up and down with periodic outbreaks of disease.[21] Only four of the corrodies examined in this paper occurred before 1392, and so conclusions based on Hatcher et al are relevant to the vast majority of the sample corrodies. To the extent there were unexpected outbreaks of disease, actual profits from the sale of corrodies would have increased.

The annuity pricing model assumes there are no non-pecuniary costs and benefits from the annuity, and the only relationship between supplier and purchaser is the cash flows (the initial price and annuity payments). This is clearly not the case for corrodies, as the corrodian usually lived in the institution. Therefore, in principle, the monetary valuation of these non-pecuniary items should be included in equation (1).

The non-pecuniary costs and benefits to the institution included extreme examples such as Lady Audely, a corrodian at Langley Priory, who took twelve dogs with her to church that created a disturbance that hindered the service (Thompson, 1918, p. 175). At Gracedieu Priory the Bishop received evidence that

[18] A sample of 133 Benedictine monasteries had an average life of 463 years, and only 13% closed due to mismanagement (including corruption). Rost et al (2008) argue this is due to their very robust governance structure. So, although monastic corruption may have occurred from time to time, this was despite the strong system of monastic corporate governance, and probably did not lead to closure of the monastery.

[19] This refers to the college of Bonhommes at Ashridge, to which the current Ashridge Business School traces its origins, and is based on the same site. This was one of only two establishments of this order in England ('House of Bonhommes', 2007, pp. 386-390).

[20] TNA SC 9/21 Edward II, October 1318, accessed using the *Parliament Rolls of Medieval England* CDROM.

[21] The first sample corrody after the Black Death in 1348 occurred in 1392. It seems likely that, in the 44 years since the Black Death, mortality expectations had normalized.

"a Frenchwoman who dwells in the priory should be removed because of the unseemliness of her life, for she receives all alike to her embraces" (Thompson, 1918, p. 122). While the institution could vet corrodians when a corrody was sold, subsequently it might be resold to someone whom the institution found objectionable. Little (1958, pp. 13-14) reports that some corrodians were required not to bring unsuitable guests into the institution. Some institutions imposed restrictions on a corrodian's behaviour. For example, at Cleeve the Jopsons were forbidden from harassing the abbey's rabbits (Williams, 1983, p. 87). Selling corrodies to couples introduced women into male institutions and vice versa, and in some cases corrodies were sold to single people of the opposite gender to that of the institution (Thompson, 1929, p. 374). The selling of corrodies and the provisions that had to be made for supplying them with food and lodgings may have had the knock-on effect of the monastery having less food for the poor and having no space for novices (Harvey, 1993, pp. 191, 198; Lewin, 2003, p. 37), and on one occasion even introduced a Jewish corrodian into Dieulacres Abbey (Hibbert, 1910, p. 15). Finally, on a more positive note, selling corrodies may have helped the institution resist the imposition of additional corrodians nominated by the Crown, while Smith (1943, p. 52) suggests that the presence of corrodians "may well have served to lighten the monotony of the monastic routine".

5 Difficulties in Conducting an Analysis of the Profitability of Corrodies

This section considers the choice of benchmark to decide whether corrodies were under or over priced, and then describes some difficulties in measuring profitability. In order to determine whether corrodies were under or over priced, it is necessary to specify some benchmark with which to compare the actual price. There are two dimensions of choice for such a benchmark: (a) the inclusion or exclusion of non-pecuniary costs and benefits, and (b) the use of *ex ante* or *ex post* data. These will be considered in turn.

Although hard to measure, non-pecuniary costs and benefits are a valid part of the profitability calculation, and economists generally argue that such costs should be included, although valuing them can be very difficult, and modern accounts exclude non-pecuniary costs and benefits. The claim that corrodies were a financial burden on institutions takes no account of non-pecuniary costs and benefits, and so they are not considered in the empirical analysis below.

Due to a lack of diversification across many corrodies, substantial longevity risk remained for the few corrodies held at an institution, and the outcome may have been a large profit or loss. On average, about half of corrodians will have died after the date given by mortality tables (if they had been available). This leads to two different, but related questions that can be asked about financial profitability:- (a) were the prices *ex ante* sensible, and (b) were they *ex post* profitable. All that can be expected of institutions is that they set prices which were sensible *ex ante*, accepting that in many cases, the actual out-turn was a loss. An *ex ante* benchmark is used in the empirical analysis below. However, following modern accounts, profitability is often thought of as an *ex post* concept. If institutions decided to sell corrodies this could easily result in a loss and they were, as Thompson (1947, p. 174) pointed out, gambling on longevity. Modern insurance companies that sell annuities have to meet statutory capital reserve requirements, and a prudent medieval institution that sold corrodies should have held sufficient capital reserves to support such a risky business. Some of the financial difficulties experienced by institutions may be explicable as normal business risks, coupled with inadequate capital reserves.

Once the benchmark has been defined, there are a range of difficulties for those seeking to measure whether corrodies were fairly priced; making the *ex ante* (or *ex post*) profitability of medieval corrodies very hard to ascertain. Corrodies were individually negotiated, and so the price and the goods and services supplied were often different in each case, as was the life expectancy of the individual or couple. Therefore a profitability analysis needs to be conducted for each corrody, and the conclusion from one corrody need not apply to another.

The initial life expectancy (or even the age) of corrodians required for computing *ex ante* profitability is usually unknown, and Keil (1963-64, p. 113) concludes that there is not enough information available on the longevity of corrodians to determine profitability. Snape (1926, pp. 143-4) concluded that there is an absence of data on the success or otherwise of the monastic officials in estimating life expectancy, that is expected life against actual life. When computing *ex post* profitability, there is little information on the actual longevity of corrodians. One exception is a sample of 66 corrodies at St Leonard's Hospital York for which Cullum (1991, p. 26) calculated that the average period to death for corrodians from the time the corrody commenced was at least 8.7 years (men 8.1 years and women 10.7 years); and that the average period until death for nine of these corrodians was 11.4 years.

Since there is usually a time lag of many years between the sale of a corrody and its completion, working out the *ex post* financial profitability of a particular corrody requires long term record keeping. The supplying institutions did not account separately for corrodies, and so there is little contemporaneous data available on *ex post* profitability.

Institutions may have deliberately subsidized corrodies by selling them at below cost to deserving individuals as an act of charity (Knowles, 1961, p. 266). In this case the corrody may be underpriced, but as the result of a deliberate policy by the institution to donate this amount to the corrodian. For Westminster Abbey, Harvey (1993, pp. 200, 204) has pointed out that most corrodians were previously known to the abbey.[22] In such cases the price of the corrody may have been affected (up or down) by these personal relationships. Williams (1983, p. 84) also mentions that corrodians appear to have had local connections.

Finally, there is a need to value the goods and services supplied to the corrodian, and this is not always straightforward; for instance the use of a garden. Where the corrody was purchased with land, Keil (1963-64, p. 113) argues that there is not enough information available on the value of the property transferred for accurate profitability calculations. Some corrodians agreed that, on death, they would leave all their assets to the institution, and this promise is hard to value when the corrody is initiated (Coulton, 1936, p. 663; Little, 1958, p. 10, Williams, 1983, p. 87). Some corrodians agreed to pay for the construction of the building where they lived, which passed to the institution on their death; while in other cases the institution put up a building for them to live in, and there may be problems valuing these buildings (Little, 1958, pp. 14-15).

6 Cash Flow Analysis

Institutions sometimes needed cash to cope with financial difficulties, for instance to cover short term liquidity problems, repay a loan, or invest in new building projects. Keil (1963-64, p. 114) reports that the sale of corrodies was used to repay loans, and Little (1958, pp. 14-15) and Lewin (2003, p. 37) state that the sale of corrodies was used to raise money for the construction of buildings, and for other forms of capital investment. Therefore the sale of corrodies could help an institution by offering a way round capital market imperfections, and this benefit may be overlooked when considering their profitability.

The time profile of the cash flows for an institution selling a corrody for cash appears in figure 1, and shows a large cash injection at time 0 (i.e. OP), followed by a small cash outflow in subsequent years (i.e. OC) until year T; where T is the date of death of the nominee, and so is uncertain when the corrody is sold. After the large inflow in the initial year, the corrody was just a drain on the financial resources of the institution, and so is likely to have been seen as a burden by the institution.

This pattern of cash flows also exposed the institution to a number of problems. Harvey (1993, p. 180) and Lewin (2003, p. 37) point out that selling corrodies for cash could tempt the monks to live beyond their means, as the money is received now, while the obligations are in the future. Squandering the proceeds of the sale may have induced financial problems for the institution. A large cash flow also created the potential for some or all of the sale proceeds to be stolen by a corrupt church official.

[22] For instance acting as their school master, employed as a mason by the abbey, a draper who supplied clothing to the abbey, a valet in charge of the abbey's refectory, or people who occupied houses in the locality of the abbey.

Figure 1. *Cash Flows When a Corrody is Paid for with Cash*

7 Empirical Analysis

Although age and life expectancy data is not available, it is possible to investigate the extent to which corrodies were priced using an *ex ante* benchmark in accordance with equation (1).[23] This will be done using data for two samples: single and joint life corrodies. As with all medieval research, the data available for conducting this empirical analysis have limitations. The survival of information on corrodies is not uniform between institutions, and corrodies purchased by a transfer of real estate are not included in the empirical analysis due to difficulties in pricing the land or buildings transferred.[24] For the remaining corrodies, even when a purchase is acknowledged, the amount paid by the corrodian, or the annual value of the corrody, are not always detailed. For the corrodies examined below, the cash value of the annual benefits in kind is available because these institutions were subject to an episcopal audit sometime during the life of the corrody. For instance, the audit of St Leonards Hospital, York occurred in 1399, and reported on corrodies sold between 1392-99 which were between three and seven years old. Since inflation was near zero (Clark, 2004, appendix table 4) the cash value of the corrody at its start would have been little different from the audit valuation.

The two samples used in this paper represent all the available English observations where the price of the corrody and value of the annual benefits were recorded. Therefore the results cover the known English population of such corrodies, and so provide definitive results for this type of corrody. The question is the extent to which these corrodies are representative of corrodies more generally?

No figures are available on the distribution of corrodies by type or year granted. In order to provide some information on these questions, the survey of corrodians at Westminster Abbey between 1100-1540 provided by Harvey (1993, pp. 239-251) was analysed. Her survey details 69 different corrody transactions for 86 individuals (i.e. single corrodians and married couples). 36 corrodies were granted to individuals (41%), either from a request by the King or for other services to the Abbey; 20 individuals (23%) purchased a corrody for a specified cash sum, while a further 11 (13%) purchased a corrody for an unspecified sum, or as part of a loan deal. Finally, 20 corrodies (23%) were granted in exchange for real estate. Therefore, 58% of corrodies were sold, and 61% of these corrodies were paid for in cash,

[23] The claim is that corrodies were a financial burden on institutions, irrespective of any non-pecuniary costs and benefits. Therefore non-pecuniary costs and benefits will not be considered in the empirical analysis.

[24] It is assumed there is no systematic link between the profitability of corrodies and the method of payment of the purchase price.

suggesting that corrodies purchased for cash formed the bulk of the business.

Our sample spans the years 1316 - c. 1460, covering a period of around 150 years. Although a long period to investigate, it allows us to discount any particular event such as plague or famine that may have led to monasteries looking to sell corrodies. In order to test the representativeness of our sample, the chronological distribution of the corrodies analysed in this paper was compared with that for the corrodies considered by Harvey (1993, pp. 239-251). The frequencies shown by the Harvey survey, followed by those for this paper's two samples are: pre 1310 - 30% and 0%; 1311-1399 - 44% and 69%; 1400-1460 - 22% and 31%; post 1460 - 4% and 0%. There are some clear differences between the two frequency distributions, with a much higher frequency for the pre-1310 period in Harvey's sample, and a bunching of the data used for this paper around 1390-1400. The conclusions reached below are conditional on the representativeness of the sample data analysed in this paper, but there is no reason to believe it is not broadly representative of corrody pricing in the fourteenth and fifteenth centuries.

The 27 individual and 24 joint life corrodies analysed below are drawn from eight religious institutions, including one hospital, one priory and six abbeys. We have been able to utilise one original source from The National Archives for the majority of the data (30 of the 51 records). This is from a visitation made in 1399 to St Leonards Hospital, York.[25] We have also mined the records of the Visitations in Lincoln, compiled by Thompson, and taken the remaining data from a detailed search of other secondary sources. The nature and financial state of the institutions selling corrodies are not discussed because it is irrelevant to appraising whether they were setting actuarially fair prices.

To compute the corrody prices given by equation (1) it is necessary to use an expected real interest rate for the life of the corrody that reflects the credit status of the institution, for example the rate at which the institution could borrow money. Despite the ban on usury, during the middle ages interest was charged on loans, both explicitly and implicitly. Cross sectional interest rates vary with credit risk, maturity, liquidity and any special conditions attached to the loan, while the general level of real interest rates varies over time with economic conditions. With imperfect competition, interest rates may also vary from lender to lender.[26]

Clark used rent charges to estimate nominal riskless interest rates and land rents to estimate real riskless interest rates for 50 year periods. These agreements were very low risk, making the implied rates

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[25] TNA C 270/21. This source is discussed in Cullum, (1991).

[26] For discussion of medieval interest rates and some long standing misconceptions, see Bell, Brooks and Moore (2009).

effectively risk free rates. Clark (2004, appendix table 4) also constructed an index of the prices of 26 farm outputs, and this was used to convert the nominal rates for rent changes to real interest rates. This gives 117 real riskless interest rate observations for the period 1251-1600.[27] However, most of these observations are for the first and last 50 year periods, with fewer observations for the intervening periods. Since real interest rates followed a downward trend during this period, weighted least squares was used to fit a time series regression to estimate the real riskless interest rate for each 50 year period. This gives the following real riskless interest rates: 1301-1350 - 8.6%, 1351-1400 - 7.8%, 1401-1450 - 6.9%, 1451-1500 - 6.0%.

To estimate the real interest rate charged on loans to institutions, allowance must be made for the institution's credit risk and the liquidity of the loan. Monasteries would very probably have spent the receipts from corrodies on buildings, buying (or repurchasing) land, repaying loans, and paying taxes to the pope and king. So the risky interest rate at which monasteries could borrow is the most appropriate discount rate. Therefore the rates charged on risky loans are relevant, as they give a more direct estimate of the cost of capital to institutions. Interest rates on risky loans suggest the presence of a substantial risk premium for medieval monasteries. In their study of the medieval wool trade, Bell, Brooks and Dryburgh (2007) demonstrated that the nominal annual interest rates implicit in 22 forward contracts entered into by monasteries from 1259-1292 averaged between 18% and 22%.[28] Since the annual inflation during this period was −0.31% (Clark, 2004, appendix table 4) the average real risky rate was about (20% + 0.3%) = 20.3%, giving a risk premium of about 10%, relative to the real riskless rate of 9.5% for the 1251-1300 period. Little other authoritative evidence is available on the monastic risk premium.

The current risk premium required for investing in UK equities, rather than government debt, is around 4% per year, and has been reasonably stable over the past century or more.[29] To be cautious, rather than 10%, a risk premium of only 4% will be used. Understating the risk premium reduces computed monastic profits from selling corrodies. The regression equation estimated above was used compute the riskless real interest rate applicable to each year.[30] A risk premium of 4% was then added to give the

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[27] Clark (2007), pp. 174-175, found little regional variation in riskless nominal interest rates across England.

[28] Eldridge and Maltby (1992) found that wool sales by Fountains Abbey had implied interest rates of between 40% and 59% per year. However, these figures were corrected by Bell, Brooks and Dryburgh (2007, p. 377), to 17% and 22%. While implicit interest rates include transactions costs incurred by the lender, these were low for long term forward contracts.

[29] See, for example, Dimson, Marsh and Staunton (2002)

[30] $r = 10.3187 - 0.8679T$, where $T = 1, \ldots 7$.

risky rate applicable to the particular year when each corrody was sold. Therefore the interest rate used below in computing the real rate of institutional profit varied from year to year. Since definitive information on real interest rates for institutions in the middle ages is not available, the pricing calculations in tables 2 and 4 use real interest rates of 5%, 10%, 15% and 20%. These real rates have been chosen to span the range of likely risky interest rates. The significance tests below use the interest rate specific to the half century in which the corrody was sold.

Single Lives. The data for corrodies on a single life, where the goods and services received by the corrodian were valued by the institution at the time of the agreement, are set out in table 1. The data in this table will be analysed in three different ways; each dealing with the lack of life expectancy data using an alternative methodology – (a) immortal corrodians, (b) the life expectancy implied by the price, and (c) the internal rate of return (IRR) using an assumed life expectancy.

The first method (immortal corrodians) of analysing the data in table 1 is to look for corrodies whose price was above that for the corresponding perpetuity (V_p in equation 2). Since none of these corrodies were perpetuities, the price of the perpetuity gives an upper bound for corrodies priced using equation (1), and any corrodies priced above this level were overpriced, relative to equation (1). Where the price of a corrody breached this upper bound, the size of the excess is given in bold in table 2. For example, corrody 4 (unnamed of Westminster Abbey) breached this upper bound for all the interest rates considered. If interest rates were 5% per year and this corrodian lived forever, Westminster Abbey would make a profit of £43 6s 8d, while the unnamed corrodian would have made a corresponding loss. Of the 27 corrodies on a single life considered in table 2, 24 breach this upper bound when the interest rate is assumed to be 20%, while nine breach or hit it with a 10% interest rate. This suggests that, at least for the sample of corrodies considered, there was substantial overpricing if real interest rates were about 10% or higher, since the lowest of the estimated risk-adjusted real interest rates for the entire data period is 10.0%. For cases where the perpetuity upper bound is not binding, there is no indication of whether corrodies were fairly priced; and this will now be considered.

The second approach to analysing the data in table 1 is to compute the implied life expectancy (ILE) by solving equation (3) for the implied life expectancy.

$$V_a = \sum_{i=1}^{ILE} \frac{A}{(1+r)^i} \qquad (3)$$

where V_a is the actual price of the corrody. The implied life expectancy gives the expected years of life the institution was using when setting the price of the corrody, given that the institution was pricing corrodies according to equation (1).[31] In effect, the implied life expectancy is the break even life expectancy. If the corrodian dies before reaching their implied life expectancy the institution makes money, while if the corrodian lives for a longer period he or she makes a profit. When the discount rate is zero the implied life expectancy equals both the expected years of life and the years purchase (or undiscounted payback period). The values of implied life expectancy are shown in table 2, which also shows the years purchase (or implied life expectancy for a zero discount rate, or undiscounted payback period). For example, if the real interest rate was zero and Robert de Bentley (corrodian no. 1) died within 7.28 years, Bolton Abbey would have made a profit, and Robert would have made a loss. If the interest rate was 5%, then Bolton Abbey would have made a profit and Robert a loss if he died within 9.26 years. Finally, if the real interest rate was 15% or higher, Bolton Abbey would have made a profit, and Robert a loss, even if Robert lived forever.

For single lives, the average implied life expectancy for a real interest rate of 10% is 23.5 years (assuming a life expectancy of 40 years for corrodians whose corrody is profitable when they have an infinite life). This number understates the true implied life expectancy due to the effects of discounting and, allowing for this understatement, these corrodians may have had an implied life expectancy of something like 25 years. Comparing this with the estimate of average corrodian life expectancy of 11.4 years by Cullum (1991, p. 26) leads to the conclusion that, for real interest rates of 10% and above, corrodies on single lives were substantially overpriced.

The final way of analysing the profitability of corrodies is to assume a life expectancy (11.4 years),[32] and compute the IRR of the resulting cash flows ([1] Brealey, Myers and Allen (2006, pp. 91-93). Since the implied life expectancy is less than the true expected years of life, setting the implied life expectancy equal to 11.4 implies a longer true life expectancy, for instance 12 to 13 years. These IRRs appear in the rightmost column of table 2. When someone buys a corrody they are effectively surrendering the purchase price now, in exchange for a sequence of annual cash flows. The IRR of a corrody gives the rate of return received by the corrodian on their 'investment' in the corrody, in other words the rate of return on the capital that remains tied up in the investment. The institution may use the purchase price to repay loans or make capital investments, and the institution receives a return on the purchase price equal to its borrowing rate, while the cost of the corrody is its IRR. The bigger is the spread between the IRR and the institution's borrowing rate, the higher is the institution's profit on the corrody. The average IRR in table 2 is 6.8%, with considerable variation between corrodies from a high of 29.5% to a low of

[31] The implied life expectancy is actually a bit less than the expected years of life due to the effects of discounting (Alter and Riley (1986), p. 12).

[32] Following Cullum (1991), p. 26.

−12.3%. This dispersion may be due to deviations in the life expectancy of the corrodian from the assumed average of 11.4 years.

If real interest rates were 10.0% (the lowest estimated risk adjusted rate), since corrodies yielded corrodians an average real return of 6.8%, institutions made an average profit of 3.2%. Using the real interest rates applicable to each year, the average institutional real rate of profit was 4.8%. On this basis, there was plenty of scope for covering any non-pecuniary costs less benefits, administration costs and adverse selection costs from supplying a corrody.

Joint Lives. As well as data on single life corrodies, it is also possible to analyse the available data on a separate sample of joint life corrodies. The equivalent of equation (1) is more complicated for joint life annuities. There are two main types of joint life annuity - (a) 100% payout while both nominees are still alive, and *y*% to the last survivor; or (b) 100% while the primary nominee is alive, and *y*% when only the secondary nominee is alive, with a different pricing model applying in each case (Brown and Poterba (2000). Williams (1983, p. 79) reports that both types of joint life corrody existed. The data on 24 joint life corrodies appears in table 3, while the results for the first way of analyzing the data showing the profit (in bold) made by the institution, assuming both corrodians lived forever, appear in table 4. For real interest rates of 15% and 20%, all but one of these corrodies was profitable if the corrodian lived forever, while for real interest rates of 10%, half were profitable with immortal corrodians.

For joint life annuities, the concept of an implied life expectancy is problematic as two lives are involved. Equation (3) can be used to compute an implied life expectancy for joint life annuities, but interpreting this number is more difficult. The implied life expectancy for a joint life annuity is the weighted average life expectancy of the husband and wife, where the weights are based on the values of the full annuity and the survivor annuity. Table 4 contains the implied life expectancies for the joint life corrodies. The right hand column of table 4 contains the IRRs of the cash flows for each corrody, assuming a weighted average life expectancy of 13 years. The implied life expectancy used for joint lives has been increased from 11.4 years because, in the absence of perfect correlation, the joint life expectancy (where the two life expectancies are weighted by the values of the joint and survivor annuities) is almost certainly longer than the single life expectancy (Jagger and Sutton, 1991; Spreeuw and Wang, 2008; Parkes, Benjamin and Fitzgerald, 1969).

When the real interest rate is 10%, the average implied life expectancy for joint life corrodies is 31.9 years (assuming a joint life expectancy, allowing for the lower benefits received by the survivor, of 40 years when a perpetuity is profitable). This indicates that joint life corrodies were also substantially overpriced.

The average IRR for corrodies on joint lives is 3.4%; indicating that joint life corrodies were more profitable for institutions than single life corrodies. For real interest rates of 10.0%, institutions stood to make an average profit of 6.6%. Using the real interest rates applicable to each half century, the institutional rate of profit was 8.2%.

Significance Tests. The institutional rate of profit on each corrody (the real risky interest rate applicable for the year when the corrody was sold minus the IRR on the corrody), will now be used to investigate whether the average institutional excess real return is significantly positive, as suggested above; or whether the average excess real return was zero or negative, as claimed by historians and medieval bishops. There is probably a positive correlation between longevity and corrody prices, resulting in an increase in the standard deviations of the IRRs computed using a common life expectancy, which decreases the chances of a statistically significant result.

Before proceeding to apply *t* tests, which assume normality, the distributions of single and joint life institutional returns were examined to see if normality can be rejected. The Jarque-Bera test statistics are 5.48 for single lives and 8.81 for joint lives. For single lives, normality cannot be rejected at the 5% significance level, indicating that the sample data appears to be normally distributed. Normality is rejected for the joint lives due to the inclusion of the corrody for William and Mary Kewe which has the exceptionally high IRR of 18.2%. If this observation is removed, the Jacques-Bera statistic drops to only 0.54, which is consistent with normality at the 1% significance level. Therefore this observation is dropped for the significance tests, leaving 23 observations with a normal distribution.

The mean real return to institutions is 4.8% on single life corrodies, and 8.9% for joint lives, while the standard deviations (s) are 8.96% for single lives and 3.36% for joint lives. A one tailed t test was used to examine the hypothesis that the average institutional excess real return (z) was zero or negative, against the alternative hypothesis that the return was positive. For single life corrodies the t value is $t = [z \times \sqrt{n}]/s$ = [4.8×5.196]/8.96 = 2.78. The null hypothesis of a zero or negative real return is rejected at well above the 1% level of significance, and the alternative hypothesis that the average institutional excess real return on single life corrodies was positive is accepted. Similarly for joint life corrodies the t test is t = [8.9×4.796]/3.36 =12.70, which is significantly positive at a very high level of significance; confirming the alternative hypothesis that institutional excess real returns on joint life corrodies were positive.[33] Both of these results support the view that corrodies were overpriced.

[33] For the full sample of 24 observations, the *t* value is 8.71. Instead of deleting the third observation, bootstrapping was used to test the significance of the sample of 24 joint lives.10,000 samples with 24 observations each were drawn with replacement. The distribution of the 10,000 sample means was computed to give a 99%

8 Conclusions

This paper has described how medieval bishops took a negative view of selling corrodies; a view which has been repeated by historians. These two groups condemned the sale of corrodies because they were thought to be financially damaging to institutions, and because they subverted the religious purpose of the institutions. However, the institutions themselves continued to sell corrodies, despite episcopal criticism; suggesting that the institutions expected to derive a benefit from selling corrodies.

The data available for investigating the profitability of corrodies, although limited and imperfect, has not previously been investigated using actuarial techniques. It is argued that, while medieval institutions were not formally capable of applying annuity pricing models, they may have been able to set prices broadly in line with such models. After considering the difficulties of measuring the profitability of corrodies, an annuity pricing model was used to investigate the implied life expectancies of single and joint life corrody prices, and the IRR for a specified life expectancy. In contradiction of the established view that corrodies were underpriced, it was found that many corrodies were profitable. This conclusion was supported by showing that institutional real rates of return on both single and joint life corrodies were significantly positive.

If, as the empirical analysis suggests, the sale of corrodies was usually financially profitable, why was it universally condemned by medieval bishops? A simple explanation is that after the first year, corrodies sold for cash were a pure financial burden on the institution until the corrodian died, and those sold for land showed no net financial benefit to the institution until well after the corrodian died.

At any one time most institutions had only a few corrodians who had purchased their corrody. Therefore, even if the corrodies had been sold at an actuarially fair price, some of the corrodies would show an *ex post* financial loss. In some cases such losses would have been substantial due to the corrodian surviving for many years beyond their expected terminal age. By selling corrodies in small numbers and foregoing the benefits of diversifying away the specific longevity risk, institutions exposed themselves to a "white knuckle ride" of profit and loss, depending on their particular longevity experience; probably without the requisite capital reserves to absorb the financial losses.[34] In addition, there may have been some confusion between the financial effects of corrodies that had been sold, and the effects of other corrodies, for instance royal corrodies; which were a pure financial burden.

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lower confidence interval of 8.11%, confirming that the sample mean of 8.2% is very significantly positive.

[34] One way for institutions to reduce their longevity risk would have been to substantially increase the number of corrodies they sold, thereby diversifying the longevity risk. In this scenario, institutions would effectively have been running old people's homes with an initial flat (non-refundable) fee, rather than monthly or annual fees.

When assessing the profitability of corrodies, medieval bishops may have underestimated the effects of the high real interest rates at which institutions could borrow in reducing the present cost of providing future goods and services. Even if the institution supplying the corrody was in financial difficulties, this need not have been caused by the sale of corrodies. Many other factors affected the overall financial position of institutions, and without controlling for these other factors, any financial problems cannot be attributed to the sale of corrodies. For example, Kershaw (1969, p. 329) reports that Bolton priory sold corrodies when they were in financial difficulties, and the sale of corrodies may have been a symptom of financial difficulties, not their cause.

There was also an absence of data on which to base authoritative *ex ante* or *ex post* profitability computations, which just left impressions; distorted by the above effects. Medieval bishops may have disapproved of selling corrodies for non-financial reasons. For example, the bad behaviour of some corrodians, bringing women into male institutions (and vice versa) and the presence of lodgers who had nothing to do with the religious purpose of the institution. Finally, the sale of corrodies may have diverted resources from the sick and poor to feed corrodians, and reduced the recruitment of novices to free up resources to service corrodians. Of course, this only applies if corrodies were unprofitable, and could have had the opposite effect if they were profitable.

Despite episcopal condemnation, institutions continued to sell corrodies. It has been demonstrated that, for the two samples of corrodies analysed in this paper, prices were set so that in *ex ante* terms corrodies offered substantial profits; although *ex post* some corrodies lost money. Selling corrodies for cash gave an immediate inflow of money, while the cash outflows were spread out into the distant future. This ready source of cash was a welcome addition to the institutional finances. It is perhaps unfortunate that the sale of corrodies provided a tempting opportunity for officials to divert this cash for corrupt purposes.

There has been no previous detailed analysis of the profitability of corrodies, probably because of the absence of life expectancy data; and academic researchers may have accepted the condemnatory views of the medieval bishops. By using actuarial techniques, this paper has demonstrated that medieval institutions, on average, appear to have made sensible pricing decisions when selling corrodies; which appear to have been over, rather than under priced.[35] That they may not have invested the cash wisely, or indeed squandered it, does not detract from the apparent profitability of this business for institutions.

[35] While the sale of corrodies may have generated financial gains for institutions, it is possible, but unlikely, that the non-pecuniary costs of corrodians to institutions outweighed the non-pecuniary benefits by a margin sufficient to eliminate the financial gains.

Finally, if corrodies were over priced by institutions, why were individuals willing to pay inflated prices to retire in a religious institution? One possible explanation is that the non-pecuniary benefits received by corrodians were highly valued by them. These may have included the monks praying for corrodians and their parents (Harvey, 1993, p. 195; Little, 1958, p. 11; Williams, 1983, p. 87); the provision of social and health care, and relieving a corrodian of the burden of managing his estates (Moorman, 1945, p. 271). The weak bargaining position of potential corrodians, coupled with insufficient competition between institutions then failed to remove the resulting excess institutional profits. Future research could be directed to discovering whether this is a realistic explanation.

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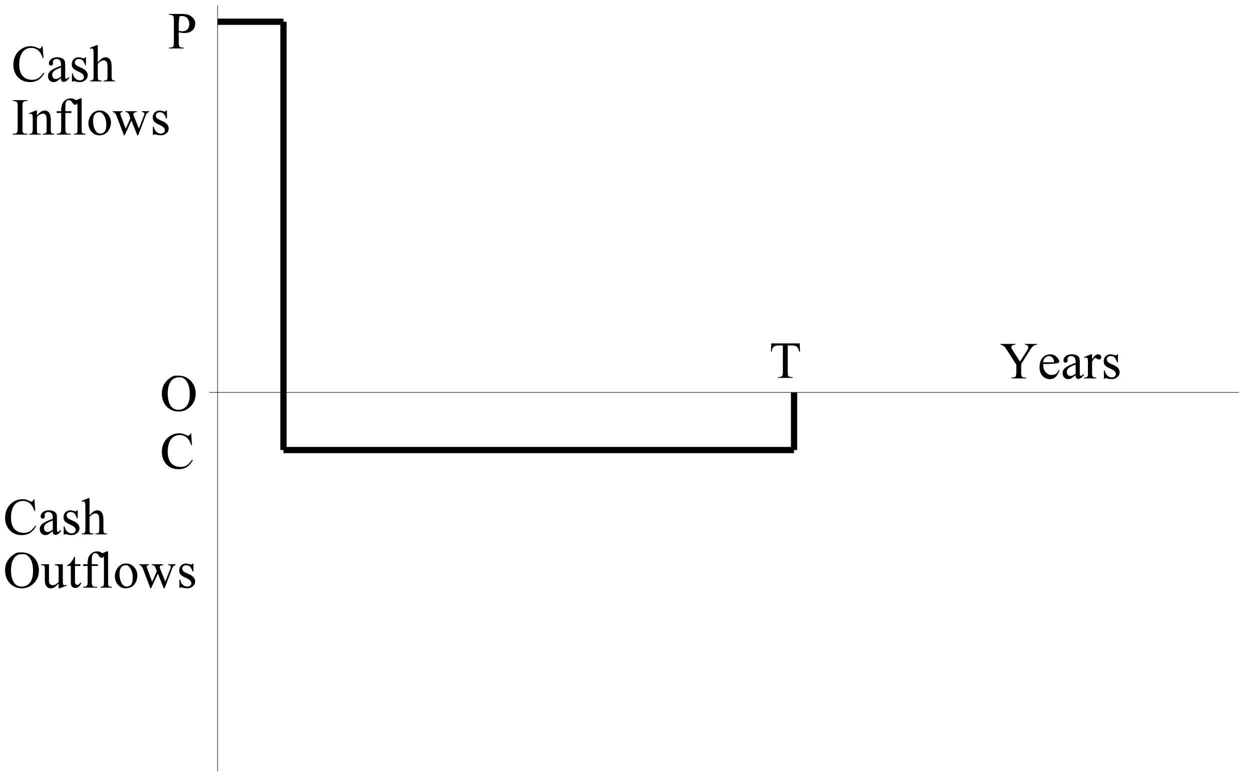
Figure 1: Real Cash Flows When a Corrody is Paid For with Cash



Institution	No.	Name of Corrodian	Year Begun	Price	Annual Payment
Bolton Abbey[1]	1	Robert de Bentley	1316-17	£80 1s 0d	£11 0s 0d
	2	Adam Propheet	1317-18	£53 6s 8d	£4 0s 0d
	3	Man of Lonesdale	1318-19	£40 0s 0d	£4 0s 0d
Westminster Abbey[2]	4	Unnamed	c1400	£150 0s 0d	£5 6s 8d
Westminster Abbey[3]	5	John Pykeworth	1418	£40 0s 0d	£8 7s 11d
	6	John Malton	c1442	£80 0s 0d	£8 7s 11d
Humberstone Abbey[4]	7	John Hardene	c1432	£6 13s 4d	£2 0s 0d
	8	Wyldebore	c1440	£66 13s 4d	£6 13s 4d
	9	William Puncharde	c1440	£10 0s 0d	£1 13s 4d
	10	John Hoise	c1440	£20 0s 0d	£2 13s 4d
	11	Robert Howet	c1440	£20 0s 0d	£2 13s 4d
	12	Robert Howet	c1440	£5 6s 8d	£1 13s 4d
	13	Richard Bekeryng	c1440	£13 6s 8d	£2 6s 6d
Laund Priory[5]	14	3 unnamed corrodies	c1336	£58 6s 8d	£11 6s 8d
Peterborough Abbey[6]	15	Thomas Mortymer	c1437	£300 0s 0d	£20 0s 0d
Thornholm Abbey[7]	16	Edward	c1440	£20 0s 0d	£2 0s 0d
St Leonards Hospital, York[8]	17	Marjorie de Botheby	1392	£26 13s 4d	£3 18s 6d
	18	Robert Brockett	1393	£26 13s 4d	£2 11s 0d
	19	John Wartyre	1393	£30 0s 0d	£3 17s 10d
	20	Katrina Andrewe	1393	£46 13s 4d	£4 9s 8d
	21	Thomas Clerk	1393	£66 13s 4d	£8 0s 0d
	22	William Selare	1394	£56 13s 4d	£5 18s 0d

[1] Kershaw (1969), table 41.

[2] Cook (1961), p. 21.

[3] Harvey (1993), pp. 248-249.

[4] Thompson (1918), p. 141.

[5] Thompson (1918), p. 178.

[6] Thompson (1929), p. 274.

[7] Thompson (1929), p. 364.

[8] TNA C 270/21

	23	Nicholas Buteler	1395	£53 6s 8d	£6 5s 0d
	24	John Fishewyk	1396	£40 0s 0d	£4 10s 0d
	25	Sir William de Neuton	1396	£40 0s 0d	£5 12s 8d
	26	William de Feriby	1396	£45 0s 0d	£6 0s 0d
	27	Agnet Salvayne	1396	£26 13s 4d	£2 13s 4d

Table 1: Data for Corrodies on a Single Life

No.	Assumed Interest Rate					IRR
	0%	5%	10%	15%	20%	
1	7.28 years	9.26 years	14.31 years	**£6 14s 4d**	**£25 1s 0d**	8.1%
2	13.40 years	22.70 years	**£0**	**£26 18s 8d**	**£33 12s 0d**	-2.5%
3	10.00 years	14.20 years	**£0**	**£13 6s 8d**	**£20 0s 0d**	2.2%
4	28.13 years	**£43 6s 8d**	**£96 13s 4d**	**£114 9s 0d**	**£123 6s 8d**	-12.3%
5	4.76 years	5.55 years	6.72 years	8.85 years	16.64 years	17.7%
6	9.53 years	13.25 years	32.05 years	**£24 0s 7d**	**£38 0s 5d**	3.0%
7	3.33 years	3.71 years	4.24 years	4.83 years	6.02 years	28.4%
8	10.00 years	14.20 years	**£0**	**£22 4s 5d**	**£33 6s 8d**	2.2%
9	6.00 years	7.30 years	9.57 years	16.42 years	**£1 13s 4d**	12.2%
10	7.50 years	9.61 years	14.50 years	**£2 4s 5d**	**£6 13s 4d**	7.5%
11	7.50 years	9.61 years	14.50 years	**£2 4s 5d**	**£6 13s 4d**	7.5%
12	3.20 years	3.55 years	4.04 years	4.60 years	5.52 years	29.5%
13	5.73 years	6.88 years	8.86 years	14.08 years	**£1 14s 2d**	13.2%
14	5.15 years	6.10 years	7.54 years	10.52 years	**£1 13s 4d**	15.8%
15	15.00 years	28.40 years	**£100 0s 0d**	**£166 13s 4d**	**£200 0s 0d**	-4.2%
16	10.00 years	14.20 years	**£0**	**£6 13s 4d**	**£10 0s 0d**	2.2%
17	6.79 years	8.49 years	11.85 years	**10s 0d**	**£7 0s 10d**	9.5%
18	10.46 years	15.16 years	**£1 3s 4d**	**£9 13s 4d**	**£13 18s 4d**	1.4%
19	8.85 years	11.92 years	22.60 years	**£7 7s 9d**	**£13 0s 10d**	4.3%
20	10.41 years	15.06 years	**£1 16s 8d**	**£16 15 7d**	**£24 5s 0d**	1.5%
21	8.33 years	11.05 years	18.74 years	**£13 6s 8d**	**£26 13s 4d**	5.4%
22	9.60 years	13.40 years	33.82 years	**£17 6s 8d**	**£27 3s 4d**	2.9%
23	8.53 years	11.39 years	20.13 years	**£11 13s 4d**	**£22 1s 8d**	5.0%
24	8.89 years	12.05 years	23.05 years	**£10 0s 0d**	**£17 10s 0d**	4.3%
25	7.10 years	8.94 years	12.90 years	**£2 8s 11d**	**£11 16s 8d**	8.6%
26	7.50 years	9.61 years	14.51 years	**£5 0s 0d**	**£15 0s 0d**	7.5
27	10.00 years	14.20 years	**£0**	**£8 17s 9d**	**£13 6s 8d**	2.2%

Table 2: Single Life - For each interest rate, the corrody was profitable for the corrodian so long as the corrodian lived more than the number of years given in each column. For interest rates which guaranteed

the institution a profit, even if the corrodian lived for ever, the table gives the loss (in bold) the corrodian would make if they lived forever. The IRR column gives the rate of return on the corrodian's investment in the corrody.

Institution	No.	Name of Corrodians	Year Begun	Price	Annual Payment
Westminster Abbey[9]	1	John & Joan Chertsey	1418	£133 6s 4d	£10 13s 4d
	2	Thomas & Joan Stone	1418	£150 0s 0d	£10 2s 6d
	3	William & Margery Kewe	1421	£40 0s 0d	£8 7s 11d
	4	Robert & Alice Drope	1460	£100 0s 0d	£8 7s 11d
Thornholm Abbey[10]	5	John Cutylere & wife	1440	£13 6s 8d	£2 0s 0d
St Leonards Hospital, York[11]	6	John Marshall & wife	1392	£45 10s 0d	£3 18s 0d
	7	Robert de Yeverslay & wife	1393	£40 0s 0d	£3 18s 0d
	8	John & Beatrice Cundall	1394	£81 0s 0d	£8 12s 0d
	9	John Willerdby & wife	1394	£46 13s 4d	£5 7s 0d
	10	John de Thwayte & wife	1394	£20 0s 0d	£2 5s 6d
	11	William Bell & wife	1394	£59 3s 4d	£6 13s 4d
	12	John Burden & wife	1394	£41 0s 0d	£4 16s 0d
	13	John Eldeslay & wife	1395	£40 0s 0d	£5 16s 8d
	14	William Sergeant & wife	1395	£50 0s 0d	£3 18s 6d
	15	Robert de Hopton & wife	1395	£66 13s 4d	£6 6s 8d
	16	Adam de Burton & wife	1395	£80 0s 0d	£8 7s 0d
	17	Stephen Nightingale & wife	1395	£66 13s 4d	£5 10s 2d
	18	William Cokk & wife	1395	£44 0s 0d	£4 15s 0d
	19	Beatrice de Selby & Isabelle de Kyghelay	1396	£66 13s 4d	£4 7s 0d
	20	Simon Smyth & wife	1396	£56 13s 4d	£5 13s 4d
	21	Robert Bird & wife	1396	£50 0s 0d	£5 2s 0d
	22	Robert Bernard & wife	1396	£23 6s 8d	£2 5s 10d
	23	Henry Thomlynson & wife	1396	£69 3s 4d	£5 17s 2d
	24	Alan Bradley & wife	1396	£33 6s 8d	£3 15s 4d

9 Harvey (1993), pp. 248, 250.

10 Thompson (1929), p. 364.

11 TNA C270/21

Table 3: Data for Corrodies on Joint Lives

No.	Assumed Interest Rate					IRR
	0%	5%	10%	15%	20%	
1	12.50 years	20.10 years	**£26 13s 0d**	**£62 4s 1d**	**£79 19s 8d**	-0.6%
2	14.81 years	27.64 years	**£48 15s 0d**	**£82 10s 0d**	**£99 7s 6d**	-3.1%
3	4.76 years	5.55 years	6.72 years	8.85 years	16.64 years	18.2%
4	11.91 years	18.53 years	**£16 0s 10d**	**£44 0s 7d**	**£58 0s 5d**	0.1%
5	6.67 years	8.30 years	11.49 years	**£0**	**£3 6s 8d**	10.5%
6	11.67 years	17.90 years	**£6 10s 0d**	**£19 10s 0d**	**£26 0s 0d**	0.4%
7	10.26 years	14.71 years	**£1 0s 0d**	**£14 0s 0d**	**£20 10s 0d**	2.5%
8	9.36 years	12.90 years	28.83 years	**£23 6s 8d**	**£37 15s 0d**	4.0%
9	9.72 years	13.62 years	37.47 years	**£16 6s 8d**	**£25 5s 0d**	3.4%
10	8.79 years	11.83 years	22.16 years	**£4 16 8d**	**£8 12s 6d**	5.1%
11	8.88 years	12.02 years	22.84 years	**£14 14s 5d**	**£25 16s 8d**	5.0%
12	8.54 years	11.40 years	20.19 years	**£9 0s 0d**	**£17 0s 0d**	5.7%
13	6.86 years	8.58 years	12.14 years	**£1 2s 3d**	**£10 16s 8d**	9.9%
14	12.74 years	20.74 years	**£10 15s 0d**	**£23 16s 8d**	**£30 7s 6d**	-0.9%
15	10.53 years	15.31 years	**£3 6s 8d**	**£24 8s 11d**	**£35 0s 0d**	2.1%
16	9.58 years	13.35 years	33.27 years	**£24 6s 8d**	**£38 5s 0d**	3.6%
17	12.10 years	19.05 years	**£11 11s 8d**	**£29 18s 11d**	**£39 2s 6d**	-0.1%
18	9.26 years	12.72 years	27.34 years	**£12 6s 8d**	**£20 5s 0d**	4.2%
19	15.33 years	29.76 years	**£23 3s 4d**	**£37 13s 4d**	**£44 18s 4d**	-3.6%
20	10.00 years	14.20 years	**£0**	**£18 17s 9d**	**£28 6s 8d**	2.9%
21	9.80 years	13.78 years	41.24 years	**£16 0s 0d**	**£24 10s 0d**	3.2%
22	10.18 years	14.56 years	**8s 4d**	**£8 1s 1d**	**£11 17s 6d**	2.6%
23	11.81 years	18.28 years	**£10 11s 8d**	**£30 2s 3d**	**£39 17s 6d**	0.3%
24	8.85 years	11.93 years	22.64 years	**£8 4s 5d**	**£14 10s 0d**	5.0%

Table 4: Joint Lives - For each interest rate, the corrody was profitable for the corrodian so long as the corrodian lived more than the number of years given in each column. For interest rates which guaranteed the institution a profit, even if the corrodian lived for ever, the table gives the loss (in bold) the corrodian

would make if they lived forever. The IRR column gives the rate of return on the corrodian's investment in the corrody.