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Do pricing points help explain rigidities in the setting of retail interest rates?

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ABSTRACT

Understanding of how prices and other measures of value are established and change is critical to modern economics. Specifically, price stickiness often observed in goods and labour markets leading to a sluggish adjustment process from the micro to macro level and competitive concerns. This study examines this phenomena through assessing the prevalence of pricing points or convenience pricing in the market for retail savings products. A database of interest rates (the price of a savings product) representative of the UK retail deposit account market from 1989 to 2011 is used to examine whether price stickiness is conditional on the direction of price change and the scale of the prevailing interest rate. Using a 100-state Markov chain process, we find evidence that rates tend cluster around certain endings and that stickiness is conditional on the direction of the price change. This finding is consistent with a profit maximising bank strategy.

Do pricing points increase interest rate rigidity?

Introduction

Can the process through which retail interest rates are established influence how these rates change? Specifically is the clustering of interest rates around certain digits, pricing points or convenient prices, associated with their rigidity? As the price system is the central market mechanism ensuring products and services are provided to those persons who value these goods or services the most (Levy 2007), comprehension of how prices and other measures of value are established and change is essential. Despite this centrality within modern economics the causes of price rigidity are a persistently disputed area of economic thinking (Wolman 2007, Blinder 1991). We address these issues by examining whether pricing points or convenient prices are associated with interest rate rigidity or alternatively are widely accepted menu cost explanations of rigidity more plausible explanations of rigidity. This work contributes to literature examining these issues in standard product markets (e.g. Levy *et al* 2011) both through applying a similar methodology to retail financial markets and also by extending these methods by considering the 'impetus' for price change.

This question is examined in the context of retail banking using interest rates from a large proprietary dataset of retail deposit accounts. In total we examine the interest rates offered on 2,519 UK retail deposit accounts issued between 1989 and 2011 by 113 firms. This study examines how these retail interest rates change using transition matrixes to investigate the probability of an interest rate change within a 100-state Markov chain process. We report that interest rates appear to most frequently change from a relatively limited set of digits to a similar form of digits. Specifically the use of fractions and whole numbers, associated with both pricing point and convenient pricing approaches are widely observed. Further change in interest rates is observed to be infrequent and associated with pricing point rather than menu costs explanations in this market.

The implications of these findings are multifaceted. These findings contribute to a growing literature examining price clustering and how such practices inhibit overall market price changes. Second, traditional assumptions linking the swift transmission of base rate changes into retail interest rates are not supported since the transmission of base rate changes into retail interest rates is slowed by the practice of using pricing points. Lastly, these practices clearly act against the interests of depositors with asymmetric responses to the theoretical cost of funds to the financial firm observed. Depositors are expected to accept a lower overall return through the sluggish adjustment to increasing market rewards compared to the more immediate reduction with falls in market rewards.

Addressing whether pricing points or convenient prices are associated with interest rate rigidity is important for many reasons, including the prevalence of pricing at a limited set of digits, the importance of price rigidity within macro and micro economic contexts and for competition and consumer protection concerns.

Initially, the clustering of prices, fees, and yields around a limited number of digits is increasingly recognized to be commonplace in financial and non-financial markets. Indubitably, price clustering has been observed in markets diverse as equity (e.g. Bessembinder 1997, Cai *et al* 2007, Christie and Schultz 1994, Christie *et al* 1994, Chung *et al* 2004, Cooney *et al* 2003, Niederhoffer, 1966; see Mitchell 2001 for a review), gilts (Ap Gwilym *et al* 2005), options (Ap Gwilym and Alibo 2003, Ap Gwyilym and Verousis 2013), IPOs (Kandel *et al* 2001), foreign exchange (Sopranzetti and Datar 2002, Sonnesmans 2006), asset markets (Grossman *et al* 1997), swap markets (Liu and Witte 2013, Meng *et al* 2013), the setting of tax rates (Ashworth et al 2003), house prices (Palmon *et al* 2004), oil markets (Bharati *et al* 2011), mergers and acquisitions (Baker *et al* 2012), supermarket pricing (Levy *et al* 2010) and the reporting of financial accounts (Das and Zhang 2003). Moreover, such clustering has also been reported to be a feature of retail banking markets in the USA and UK (Kahn *et al* 1999, Ashton and Hudson 2007). While many influential studies of pricing have played down the influence of pricing points and clustering on price rigidity (e.g. Blinder *et al* 1998) reassessing this question in the context of this body of evidence appears timely.

Despite the widespread presence of clustering of prices and yields around a limited number of digits, the implications of this practice not as well understood as commonly assumed. Most studies of price clustering have made worthwhile contributions by testing why certain digits such as fractions and round numbers occur more frequently than other digits. It has been reported this practice persists for reasons of convenience, to reduce negotiation and comprehension costs, as a function of market characteristics or as a profit maximisation strategy. This study does not contest these theories yet examines a further issue raised in recent clustering studies (e.g. Cai *et al* 2007, Sonnesmans 2006) of how the clustering of prices around certain digits is associated with price change and rigidity of pricing.

Secondly, determining the causes of interest change and factors which impede interest rate or price changes has general and specific macro-economic implications. Generally, the presence of price rigidity influences the construction of prices indices (Bunn and Ellis 2011) and is central to how Keynesian models generate predictions; (Wolman 2007). Examining retail interest rates specifically is also important as many systems of monetary policy focus on controlling money supply through interest rate targets (Biefang-Frisancho and Howells 2002, Bunn and Ellis 2011). For example within the UK, a traditional policy assumption is that '… banks and building societies pass on any changes in the base (rate) to their customers immediately' (Heffernan 1997 p.221). Despite the significance of comprehending interest rate change, comprehension has long been a 'black box' (Dale and Haldane 1998). This study therefore contributes to this literature by determining whether pricing points or convenience pricing of interest rates are a significant factor contributing to the sluggish movement of retail interest rates.

Lastly, there are competition law implications if pricing points affect the degree of pass through of costs to final prices and artificially raise prices (Alexandrov 2013). As retail banking markets are expected to operate in a competitive manner, factors which limit the responsiveness of interest rates to freely change to competitive levels need to be identified. Reflecting this concern the competitive operation of retail banking and the setting of interest rates has been raised in the European Union (European Commission Directorate-General for Competition 2006), Australia (Australian Senate 2011) and the UK (Financial Conduct Authority 2014; 2015a, 2015b, Independent Commission on Banking 2011). In this study we contribute to these literatures by examining if pricing points arising from interest rate clustering are a factor restricting the free movement of interest rates to the detriment of depositors.

The paper is organised as follows. The next section discusses the literature. The data and methods employed are outlined in section three. The results, including a descriptive and graphical analysis and transition matrices, are reported in section four. Finally in section five concluding remarks are provided.

2. Literature review

The price rigidity and pricing of different commodities, goods and services and incidence of price clustering around certain digits has been examined by many different academic traditions, including consumer research, finance, economics, marketing and statistics. Acknowledging the scope of these literatures we focus this discussion on price and interest rate rigidity and clustering relative to financial markets and where possible retail banking. Specifically we outline why interest rate rigidity and clustering could arise and indicate past evidence of the incidence of such phenomena in different markets.

Since Means (1935) rigid, sticky or sluggish price change been widely observed. The prevalence of rigid pricing in recent years has been observed in the numerous central banking assessments of inflation persistence. These studies (e.g. Bunn and Ellis 2011, Gautier 2006, Hoffman and Kurz-Kim 2006, Kurri 2007) have involved examination of substantial micro data sets and report price rigidity is a substantial and heterogeneous phenomena over time and markets examined; concerns also supported by survey evidence (for example Hall *et al* (2000) and Blinder *et al* (1998) for UK and US firms respectively).

In light of the scope of price rigidity it is unsurprising that determining the causes of sticky prices has both a long lineage (e..g. Means 1935) and scope of explanations[1]. Prominent within the literature, Blinder *et al* (1998) examined twelve most plausible theories explaining rigid prices (see Wolman 2007, for a review). From interview data Blinder *et al* (1998) reported price rigidity arises from concerns that price changes might antagonise customers (21%), raise competitive pressures (14%) or is due to menu costs (14%).

Reflecting these results, subsequent discussion of price rigidity has relied on menu costs as a critical theoretical lynchpin (Levy 2010). It is often assumed that there are administrative and physical costs associated with altering prices and informing customers of a price change. Prices will therefore only change when the decision to undertake this action is profit maximising. While empirical evidence supporting menu cost explanations of price rigidity

[1] This literature has developed from a range of different perspectives not least of which is examining the veracity of different macro-economic models. For example much debate has been undertaken as to whether prices change in a synchronised or staggered manner between and with firms (e.g. Lach and Tssidon 1996, Fisher and Konieczny 2000) which is not outlined in detail as this is more pertinent to other debates than this.

are limited some evidence is supportive. For example Levy *et al* (2010) examined multi product retailing in settings where changing prices is more and less costly and confirmed the importance of menu cost explanations in this context

Other explanations of rigidity have also been assessed including competition and the exercise of market power. Concerns with anti-competitive arrangements appear to have importance in explanations of price rigidity and clustering in non-financial markets including oil (Bharati *et al* 2011) or petrol (gasoline) markets (Jiménez and Perdiguero, 2012). The institutional structure of markets has also been reported as influential with firms with a greater sensitivity to costs (MacDonald and Aaronson 2006), a history of frequent price changes (Campbell and Eden 2005) and high firm liquidity (De Graeve *et al* 2004) having more responsive pricing.

Explanations of interest rate rigidity specifically have been forwarded within an extensive literature examining how market or official rates of interest are transmitted to the interest rates paid on retail deposits and other financial services. These studies have linked the rigidity of interest rates with a wide array of market characteristics including yet not exclusively the competitiveness of retail financial services markets (Calem and Mester 1995; Heffernan 1997); interest rate asymmetry (De Haan and Sterken 2004), market structure, both in the US and Europe (Corvoisier and Groop 2001; De Graeve, De Jonge and Vander Vennet 2004; Hannan and Berger 1991), lending channel effects (De Graeve, De Jonge and Vander Vennet 2004), bank efficiency (Fuertes and Heffernan 2009), macroeconomic changes (Gambacorta 2008), regulation (Chong 2010) and the scale of official or base rate changes (Fuertes, Heffernan and Kalotychou 2010) as influential factors influencing the relationship between official or market rates and retail interest rates.

Price rigidity and the use of pricing points or convenience pricing arises when prices form at certain digits. The particular digits, around which prices form, depend on the context and explanations which dominate. For example, 99 is observed in many contexts if pricing point explanations dominate, or whole numbers or fractions may predominate when convenience pricing is commonly used (see Knotek 2011). Pricing points or convenience pricing has previously been identified in situations where menu costs are not substantial, such as internet book sales (Chakrabarti and Scholnick 2005), electronic markets, (Oh and Lucas 2006) and apartment rents (Genesove 2003), and situations where menu costs are significant such as catalogue sales (Kashyap 1995). Many reasons have been forwarded to explain why prices would cluster around certain digits rather than be randomly distributed across all digits. These explanations reflect concerns that the valuation of assets and contracts is subjective and based on a wide range differing assumptions.

Initially, prices may cluster around certain digits as mechanism to aid negotiation and reduce transaction costs. In essence prices are set in many markets to provide convenience. From a non-behavioural perspective, focal points (Mehta *et al* 1994) form to enable coordination. If we assumed the labelling which players use in any competitive game is critical and reflects common culture or experience and that the brain is a tool of prediction and estimation rather than a calculation device (Kopcke *et al* 2004), the use of certain numbers is a rational strategy to reduce time and effort in transactions (Basu 2006). Therefore price clustering could result as a convention in markets to reduce conflicts in decision making, limit negotiation costs and aid commerce. More widely when given a choice as to the price paid, Lynn *et al* (2013) reports a preference for round numbers over other digits reflecting the long recorded human tendency to associate with rounded numbers, halves, quarters and even numbers (Yule, 1927).

Evidence of the use of a limited number of 'convenient' prices has also been observed in many markets. In retail markets the use of convenient prices such as round numbers are seen frequently when rapid decision making is required (Knotek 2011). Within financial markets the degree and extent of price clustering around certain digits could also reflect a trade-off between the level of price transparency, the costs of negotiation (Harris 1991) and information availability (Ball *et al* 1985). Indeed the benefits of a very fine valuation relative to the loss resulting from a rounded valuation may be limited when decisions are considered in a sphere of haziness (Cai *et al* 2007) or with a degree of uncertainty. Reflecting such thinking, Ap Gwilym and Verousis (2013) examining the equity option values, reported the degree of clustering varies over time reducing with proximity to the options' expiration date, when the trading volume will increases. In a similar vein, Meng *et al* (2013) report price clustering varies within credit default swaps, reducing with the size of trades and increasing within periods of increased volatility. Considering, the U.S dollar/Taiwan dollar swap market, Liu and Witte (2013) also observe more clustering arises with the scale of the market and activity. The characteristics of the market considered may also be significant when determining the degree of price clustering. These characteristics might include the industrial structure of individual markets (Grossman *et al* 1997), cultural factors (Brown *et al* 2002), the form of trading, such as the adoption of dealer or auction markets (Huang and Stoll 2001) or the trading scales used for trading (Chung *et al* 2003, Ap Gwilym *et al* 2005). Clustering also varies with the form and format of the financial contract considered; Ap Gwilym and Verousis (2013) reported clustering has multi-dimensional aspects and occurs over price, time value and also information value components within equity options.

Distinctly, it has also been argued clustering and the use of pricing points arises from behavioural factors. In particular the predictions of prospect theory and framing (Kahneman and Tversky 1979, Tversky and Kahneman 1986) where consumers react more strongly to losses than gains, are generally risk averse for gains and risk seeking for losses, and make choices from an initial reference point could be influential. For example, the perceived gain effect would indicate that a relatively high incidence of the number 9 in prices occurs as zero could be used as a reference point. Conversely a perceived loss from a one would be disproportionate suggesting this number would be avoided in pricing. Consequently prospect theory indicates that certain numbers, such as 9 and 4 would be over represented and other numbers such as 1 and 6 are under-represented in pricing (Schindler and Wiman 1989).

Developing this rationale, Kahn *et al* (1999) viewed the decision-making attributes of depositors to be critical to this process, where retail banking markets are assumed to be populated by more and less informed customers which choose banking services with different levels of attention. In the presence of customers with varying decision making abilities banks will choose to cluster reported interest rates as a profit maximising strategy. Specifically the level of interest rate clustering is predicted to rise with the proportion of naïve or less informed customers.

Overall we observe explanations for price rigidity and clustering are diverse, overlap and include both explanations assuming benign and profit maximising explanations. The degree to which these concepts are linked in practice and the presence of clustering at certain digits be these for convenience or pricing points, is an issues explored in the next section.

3. Data, Hypothesises and Methodology

In this section we outline the key hypothesises to be examined, the data employed and the methodology.

The testing approach and key hypothesises

The testing approach employed draws heavily from the pricing point and menu cost models of pass through from Alexandrov (2013) and Kashyap (1995). Initially we assume that the interest rate rigidity of any firm *i* may be influenced by either a) pricing points or convenient prices or b) menu cost explanations of price rigidity. Further, firms decide to change interest rates or otherwise following a change in the costs of providing the deposits, be this arising from the prevailing policy or base interest rate, the costs of providing the deposit service or the demand for deposit services. We consider the change in base rates as a proxy for all such cost arguments.

If pricing points or convenient prices are influential then firms' may change interest rates to one of several pricing points. These points could represent convenience or pricing points depending on the explanation for any interest rate clustering observed. When the firm faces a change in costs of a given size, it can decide to change or keep the current price. It is assumed the optimal pricing structure is to break up possible cost changes into a continuum of potential cost values with a pricing point for each one. If the cost of change is within a certain limit or threshold then the price will remain the same. If this cost change is above this threshold then the price will change. Expressed differently, interest rate change can occur when the distance between costs and prices exceeds a certain range. The new price will be chosen from a limited number of possible prices and this price should share common features with other prices used by the firm. As we are examining deposit accounts where a price represents a benefit to the consumer, we would expect profit maximising pricing points to be consistent with convenient prices and occur at whole numbers, round numbers and fractions (see Ashton and Hudson 2007).

Alternatively if menu costs are significant the firm maximises profits from an interest rate change only when menu costs are exceeded by profits arising from the interest rate change. While this results in interest rate change if costs or demands move beyond a certain expected range, under menu cost explanations, the new price to which the firm moves will reflect a profit maximising decision and the choice of pricing digits will be a random decision.

Therefore if pricing points are more influential than menu cost explanations we would expect to observe a range of features in this market including:

a) Substantial clustering at a limited set of digits (round numbers, fractions and whole numbers).
b) Movement from pricing points (round numbers, fractions and whole numbers) to other pricing points should be more frequent than movement to non-pricing points.

To consider whether pricing point or menu cost explanations are linked to interest rate rigidity, we compare the relative speed of interest range change to underlying cost changes represented by the base rate. For the incidence of interest rate change we would expect to observe:

c) Movement from pricing points (round numbers, fractions and whole numbers) to other pricing points is associated with slower responses to base rate changes.

Data

The data used in this analysis is obtained from the monthly MoneyFacts magazine which produces a representative monthly catalogue of available UK savings products and associated interest rates. We have compiled data from this publication for the period January 1989 to December 2011 involving 276 monthly periods. Deposit accounts are particularly suited for this form of analysis. Deposits are relatively simple and widely comprehended financial services which can be readily judged on price as quality is less uncertain than other financial services such as insurance. Unlike loans these contracts are not established over long fixed periods yet vary over time.

It should be noted that the monthly format of the dataset relates to the publication date of the magazine which has been obtained from a market survey in the week preceding the previous month end, and so a date of February relates to the market situation around the 25th of January. The data includes 2,519 deposit account products from 113 firms. The product age varies from one month to 268 months in duration with a mean of 53.58 months. Of the 2,519 products included in the dataset the highest number of product observations being 268 periods, most products are observed between 50 and 100 months and no product is available for the entire sample period; 48 products are observed for only one period. In total there are 1,090,854 observations and 180,727 changes in interest rates which are examined. Rates are collected for a range of 9 initial deposit balances, ranging from £1 to £100,000.

The descriptive analysis uses interest rates from all tiers, across all products, and across all types of financial institution. In the assessment interest rates are quoted up to two decimal places, and so are somewhat discrete in nature much like goods prices. Although an explicit rule does not exist, all rates in the UK are quoted to this level of precision, with no currently marketed product using a higher or lower degree of precision.

To represent costs we examine base rates issued by the Bank of England. UK deposit taking institutions generally adjust their interest rate tariff as a result of change in the Bank of England base rate, which may be interpreted as a proxy a wholesale cost of funds rate. Over the sample period the Bank of England Base Rate has undergone 26 changes, declining from a high of 15% at the beginning of our sample, to a low of 0.5% at the end.

Methodology

The inferential element of the testing procedure considers the how interest rates change from one number to another. It is assumed within this assessment that clustering in some way influences the likelihood and magnitude of an interest rate change be this generally or in cases where we might expect an interest rate change to occur after a change in the base or policy rate.

The framework for this testing procedure assumes each deposit account can be thought of as having an initial 'state' determined by the two digit decimal ending to the rate. In this case there are 100 possible initial states which we denote $S_1 = '00'$, $S_2 = '01'$, $S_3 = '02'$, … …, $S_{99} = '98'$ to $S_{100} = '99'$.

The migrations of interest rate endings from one state (ending) to another are assumed to follow a Markov process. We acknowledge this requires independence with both previous states and with time. To analyse the dynamics of switching from one state (ending) to another, a 100-state Markov chain probability transition matrix for the last two digits of the interest rate for the probability P_{ij} of switching from state S_i in the first period to state S_j in the second (Hanson and Schuermann 2006) is estimated. The time between S_i and S_j, which is denoted t , is generally taken to be one month, though in some cases we also examine switching these transition probabilities over a two or three month window.

The counterpart of these transition probabilities are transition 'intensities' which can be calculated as summarised by:

$$\lambda_{ij}(t)=\frac{T_{ij}(t)}{T(t)}=\frac{\sum_{n=1}^{N}\sum_{k=1}^{K}T_{ij}^{nk}(t)}{\sum_{i=1}^{I}\sum_{j=1}^{J}\sum_{n=1}^{N}\sum_{k=1}^{K}T_{ij}^{nk}(t)} \quad (1)$$

where $\lambda_{ij}\left(t\right)$ denotes the sample probability of interest rate ending changes from state S_i to S_j, namely an entry of the estimated transition probability matrix. $\left(T_{ij}^{nk}\right)\forall i,j$ is a count of interest rate ending migrations from state S_i to S_j for product *n* at tier *k*.

Thus, we can obtain a matrix of migration intensities, the sample counterpart of the Markov chain probability transition matrix, denoted Λ . The main diagonal of this transition probability matrix represents probabilities for accounts which change by a full percentage point (upward or downward), since the matrix is conditional on a change in the rate occurring between states, while off-diagonal elements are for a change in ending, regardless of the level of change in the integer component of the rate.

To fully compare interest rate ending migration dynamics with a degree of statistical significance, a simple point estimate is not enough. Therefore, bootstrapped confidence intervals for these transition probabilities are constructed by resampling (with replacement) the deposit interest rates to produce 1,000 replications of Λ (Efron 1993). This bootstrapping method assumes serial product-wise independence of the interest rates.

In the following analysis we first examine price change without reference to base rates and then considerer the reaction of accounts following a base rate change stimulus. We again employ the transition matrix, this time only for the specific period of 3 months following a particular base rate movement. 6 base rate changes are identified based on the magnitude of the change in both the first month, and subsequent two months. The periods chosen are shown by the vertical bars in Figure 1a (for comparison Figure 1b shows the changes in the base rate over time), and cover a range of positive and negative moves of differing magnitude in the base (policy) rate. Each of these periods commences on a base rate change month: (23rd) November 1993, (12th) September 1994, (4th) June 1998, (13th) January 2000, (5th) April 2001 and (5th) August 2005.

Figure 1a: Base Rate Changes and Cumulative Year Bank of England Base Rate

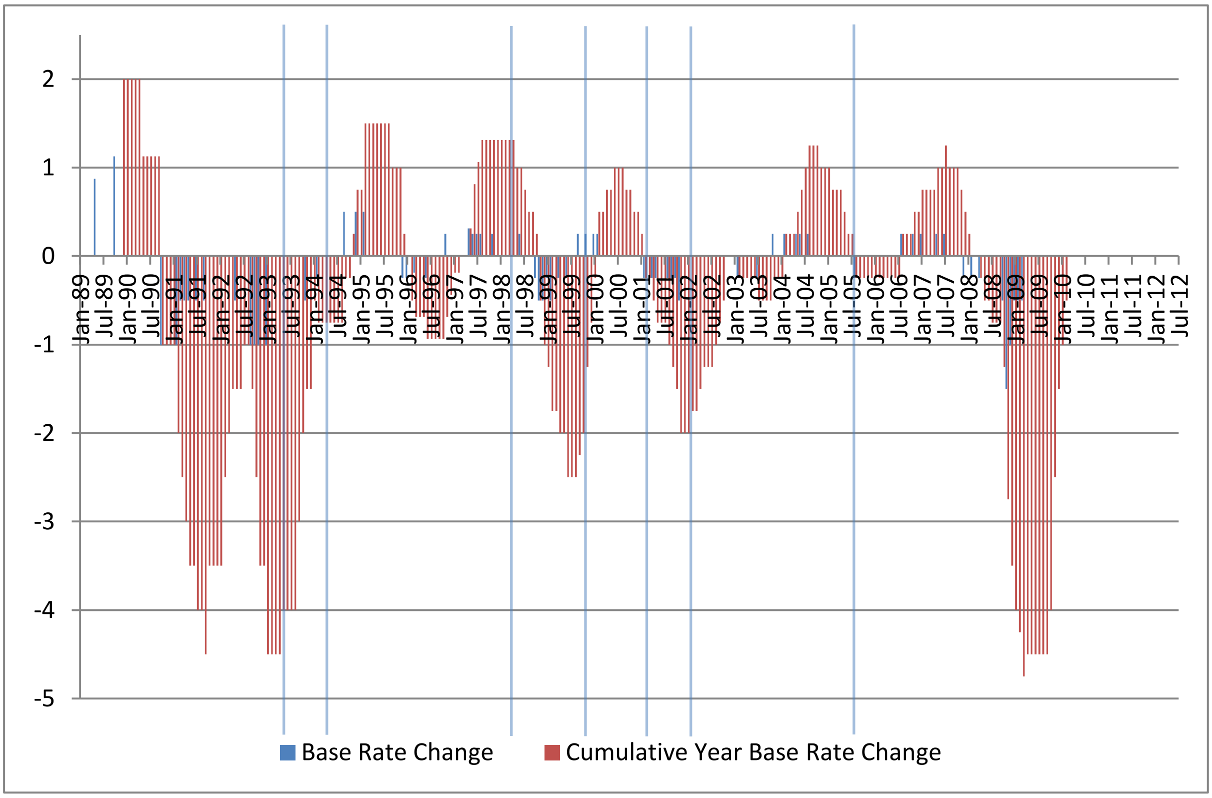
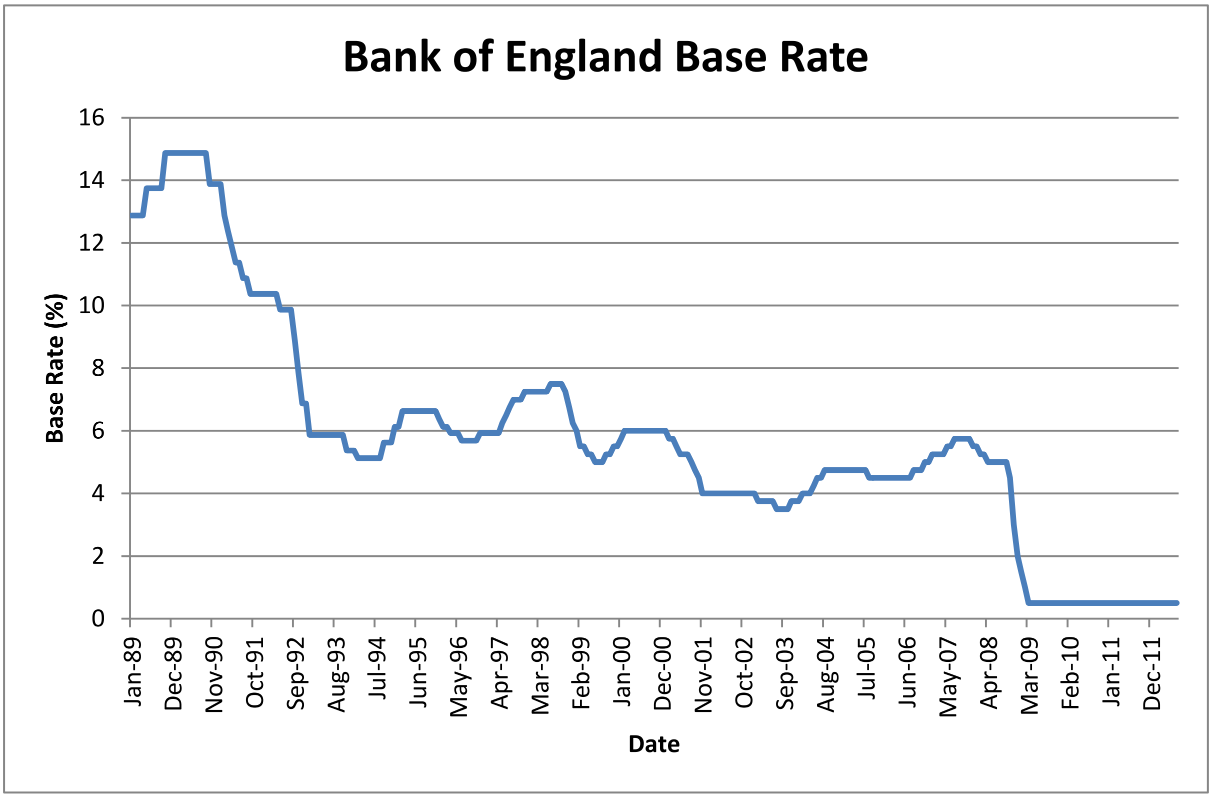


Figure 1b: Changes in the Bank of England Base Rate over Time



Note that change isn't necessarily cumulative – an account will be treated as having a positive change in the first month if its rate increases by say 0.25% in this month, yet if this is later corrected by a 0.25% reduction in the rate, the account overall will be deemed not to have changed (at either the two month, or three month horizon) hence the proportion and so probability of change might actually fall at longer horizons.

As a 'control' we also examine the movement of rates in a period where there are no Base Rate change impetus, which is shown in the subsequent tables as 0, 0, 0. The data for this is from March 2002. The results will suggest that rate change probability in such periods is very small, with less than 5% of account rates changing. As such, we would seem justified in our assumption that changes in the base rate, a proxy for the cost of funds, is the predominant incentive for firms to alter their interest rate tariffs.

This assessment is undertaken for a range of situations reflecting hypotheses b) and c). Addressing hypothesis b) that movement from pricing points (round numbers, fractions and whole numbers) to other pricing points should be more rather than less frequent we examine:

1) the probability of move to a certain value is conditional on another value for all moves and moves upwards and downwards (reported in Table 2)

2) the move from a popular ending is conditional on a change in the interest rate (reported in Table 3).

When addressing hypothesis c) that movement from pricing points (round numbers, fractions and whole numbers) to other pricing points should be associated with slower responses to base rate changes, we examine:

1) the probability of a rate change conditional on a change in the base rate (reported in Table 4).

2) The size of an interest rate change conditional on a change in the base rate (reported in Table 5).

3) the probability of move from a popular versus an unpopular ending subject to a change for 3 different deposit quantities (reported in Table 6)

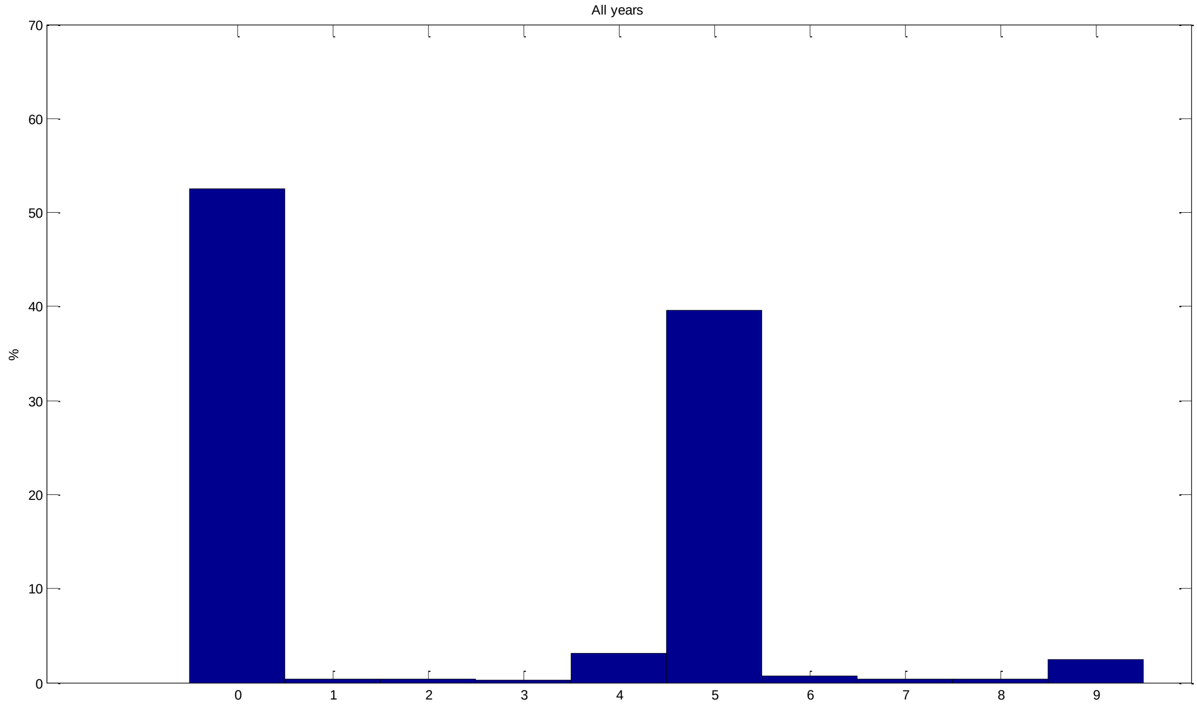
4) the size of a move subject to a popular and a non-popular ending for three deposit quantities (reported in Table 7).

4. Results

4 .1 Descriptive Analysis

We first consider the case where the final digit is clustered around a particular number and how this level of clustering has evolved over time. In Figure 2 it is shown that there is a tendency for rates to cluster around a 0 or 5 ending, with these two endings accounting for over 90% of the sample across all time periods. There is less clustering around 4 and 9 endings.

Figure 2: Final Digit Clustering



Turning to an examination of the clustering evident in the final two digits a much clearer pattern develops as shown in Figure 3. Around 28 per cent of rates are clustered at the integer, that is a 00 ending, which is around 18 per cent more of the sample than any other two-digit clustered ending. The next most popular ending is 50, at around 10 per cent of the sample, followed by 25 and then 75.

Clustering at other endings is limited to less than 5 per cent of observations, with the majority of such rates being at a decile and so having a final ending digit of a 0, so affirming the strong tendency for 0 ending final digit. We may therefore report interest rates are set at a limited number of points consistent with pricing points being influential.

Looking at the predominant two digit ending through time, namely 00, 25, 50 and 75, it is evident from Figure 4 that the overall degree of clustering has declined through time most markedly in integer clustering.

Figure 3: Two Digit Clustering

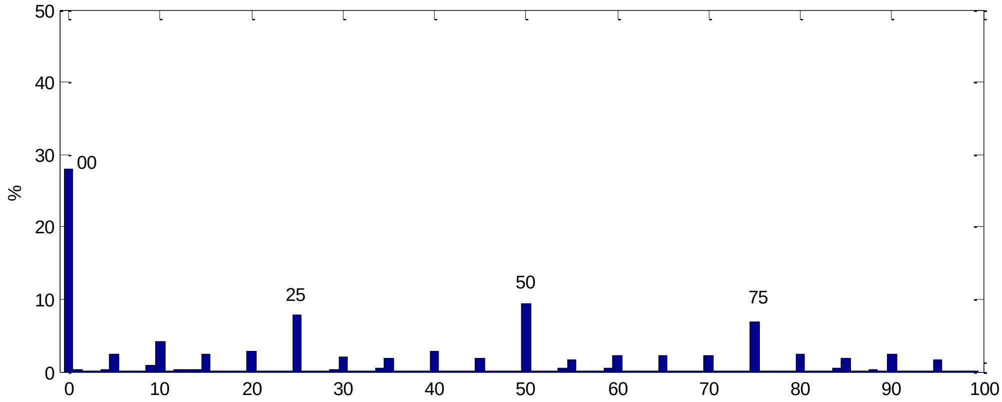


Figure 4: Level of Clustering Around a 00, 25, 50 and 75 Digit Ending over Time

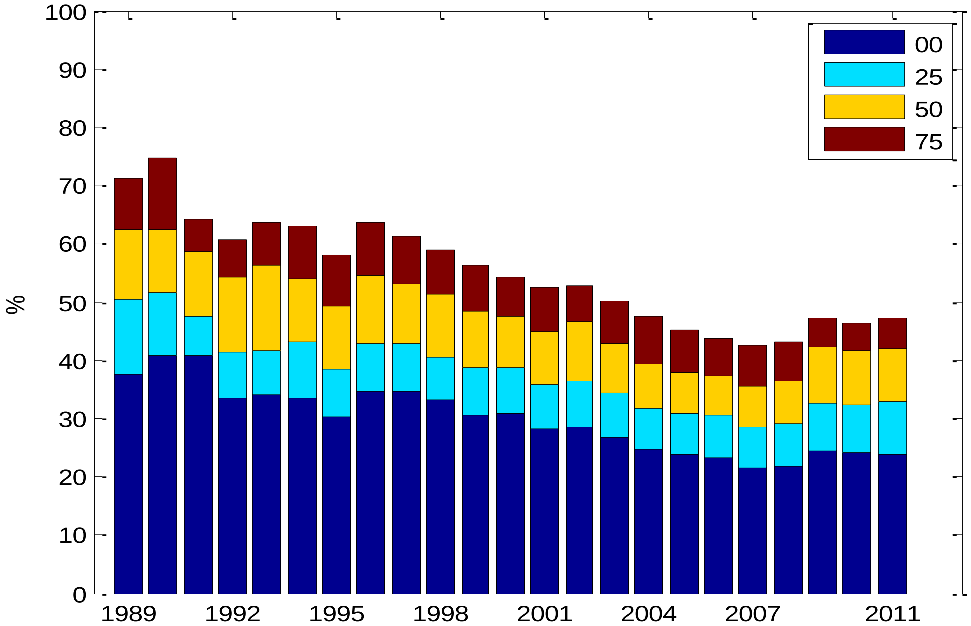


Table 1: Top 25 Transition Probabilities Conditional on a Change

	All Moves					Upward Moves					Downward Moves				
	Current Ending	Next Ending	%	95% Confidence Interval		Current Ending	Next Ending	%	95% Confidence Interval		Current Ending	Next Ending	%	95% Confidence Interval	
Rank				Lower	Upper				Lower	Upper				Lower	Upper
1	00	75	2.64	2.45	2.81	00	25	2.07	1.88	2.25	00	75	2.49	2.31	2.67
2	00	25	2.56	2.35	2.74	50	75	2.06	1.87	2.24	50	25	2.31	2.12	2.48
3	25	00	2.46	2.27	2.63	75	00	2.01	1.84	2.20	25	00	2.24	2.06	2.42
4	50	25	2.43	2.26	2.60	25	50	1.92	1.75	2.10	75	50	2.19	2.00	2.39
5	00	50	2.43	2.24	2.62	40	65	0.52	0.44	0.59	00	50	2.03	1.86	2.21
6	50	75	2.41	2.21	2.60	65	90	0.50	0.43	0.57	50	00	1.84	1.68	2.00
7	75	00	2.41	2.22	2.60	90	15	0.46	0.39	0.53	75	25	1.18	1.07	1.30
8	75	50	2.33	2.15	2.50	15	40	0.46	0.39	0.52	25	75	1.12	1.01	1.23
9	50	00	2.28	2.10	2.46	50	00	0.44	0.37	0.51	00	00	0.72	0.61	0.84
10	25	50	2.27	2.07	2.45	20	45	0.43	0.36	0.49	90	65	0.55	0.48	0.62
11	75	25	1.43	1.30	1.55	45	70	0.42	0.35	0.48	40	15	0.52	0.46	0.59
12	25	75	1.36	1.23	1.49	95	20	0.41	0.35	0.48	65	40	0.51	0.45	0.57
13	00	00	0.83	0.70	0.96	70	95	0.40	0.34	0.47	15	90	0.50	0.43	0.57
14	40	65	0.57	0.49	0.65	00	50	0.40	0.34	0.46	00	25	0.49	0.42	0.58
15	90	65	0.56	0.49	0.63	60	85	0.39	0.34	0.45	50	50	0.46	0.38	0.55
16	40	15	0.55	0.49	0.61	00	20	0.36	0.31	0.42	05	80	0.43	0.37	0.50
17	15	90	0.53	0.46	0.60	50	70	0.35	0.30	0.41	70	45	0.42	0.36	0.48
18	65	40	0.52	0.46	0.59	80	05	0.34	0.28	0.39	95	70	0.41	0.36	0.48
19	65	90	0.52	0.45	0.60	35	60	0.34	0.28	0.39	75	00	0.40	0.34	0.47
20	50	50	0.52	0.44	0.61	05	30	0.33	0.27	0.39	85	60	0.40	0.35	0.46
21	15	40	0.51	0.44	0.58	30	55	0.32	0.27	0.38	60	35	0.40	0.35	0.45
22	90	15	0.48	0.41	0.55	55	80	0.31	0.25	0.36	45	20	0.39	0.34	0.45
23	00	20	0.47	0.40	0.53	80	00	0.30	0.25	0.34	30	05	0.39	0.33	0.45
24	20	45	0.46	0.40	0.53	25	45	0.29	0.24	0.34	20	95	0.38	0.33	0.43
25	95	20	0.45	0.38	0.52	75	95	0.27	0.22	0.32	50	75	0.36	0.30	0.41

Table 2: Probability of a Move from a Popular Ending Conditional on a Change

	1 Month								
	All Moves			Moves Up			Moves Down		
	%	95% Confidence Interval		%	95% Confidence Interval		%	95% Confidence Interval	
		Lower	Upper		Lower	Upper		Lower	Upper
00	20.96	20.28	21.68	7.24	6.88	7.61	13.72	13.15	14.29
25	19.67	18.82	20.53	7.75	7.31	8.18	11.92	11.30	12.55
50	20.22	19.35	21.10	7.38	6.94	7.84	12.84	12.25	13.43
75	22.57	21.74	23.43	8.62	8.14	9.11	13.95	13.34	14.61
	2 Months								
00	37.26	36.12	38.47	13.34	12.69	13.99	23.92	23.00	24.85
25	34.98	33.50	36.44	14.16	13.46	14.95	20.82	19.80	21.86
50	35.21	33.75	36.62	13.21	12.50	13.97	22.00	21.04	22.99
75	39.81	38.42	41.22	15.63	14.83	16.48	24.18	23.11	25.23
	3 Months								
00	48.99	47.50	50.49	17.85	16.98	18.69	31.14	30.01	32.31
25	46.20	44.34	48.13	19.09	18.06	20.17	27.10	25.75	28.50
50	46.47	44.66	48.29	17.82	16.85	18.78	28.65	27.37	29.95
75	52.49	50.69	54.21	20.96	19.89	22.02	31.53	30.27	32.93

4.2 Results of the transition matrixes.

Table 1 shows the top 25 transitions in terms of their probability. The left-most panel shows the transitions for all moves, while the middle and right-most panel show these probabilities conditional on the move being upward or downward, respectively.

The most common transition in both the directional and non-directional panels is from a 00 ending. Downward moves from this category appear to account for the overall dominance of the 00 to 75 ending change probability at around 2.5% of all moves, with the 00 to 25 upward move probability of nearly 2% making this the second most frequent move within the class of all moves. It is clear that changes from popular endings to other popular endings dominate moves from non-popular endings by a factor of 4, further confirming the clustering of rates identified in the previous descriptive analysis.

Table 2 shows that given a rate ending in 75, there is a 22.57% chance that this rate will change in 1 month, 39.81% in two months, and a 52.49% probability that it will have changed over a 3 month interval. These are the largest probabilities in the table suggesting that a move from a 75 ending is more likely compared with 00, 25 and 50 ending rates. The confidence interval also supports the finding that the probability of a move is statistically significantly larger in the main for the 75 ending rates compared with nearly all other endings. Generally it is the 25 rate which is least likely of the popular ending rates to change.

Comparing moves up with moves down, probabilities of a move from a popular ending are between 1.5 and 2 times larger for moves down compared with up. This might be an artefact of the overall downward trend in base rates over the sample period, but is also consistent with a profit-maximising motive on the part of the firm. This will be examined in more detail shortly, when we look at the likelihood of a move given a directional change impetus to the cost of funds. Finally, comparing the different time intervals for all rate endings, around 1 in 5 products move in any one month, but over a 3 month interval, around 1 in 2 will have changed rates, suggesting rates are not terribly persistent. This is defensible since the economic cost of changing rates are relatively low compared to say, a supermarket, as menu costs consist primarily of interest rate publications.

Table 3: Average Size of a Move from Popular Endings Conditional on a Change

	All Moves			Moves Up			Moves Down		
	Size	95% Confidence Interval Lower	Upper	Size	95% Confidence Interval Lower	Upper	Size	95% Confidence Interval Lower	Upper
1 Month									
00	0.50	0.48	0.51	0.40	0.37	0.42	0.55	0.53	0.56
25	0.45	0.43	0.47	0.39	0.36	0.42	0.49	0.47	0.51
50	0.47	0.46	0.49	0.37	0.35	0.40	0.53	0.51	0.55
75	0.45	0.43	0.46	0.38	0.36	0.41	0.49	0.47	0.50
2 Months									
00	0.55	0.53	0.57	0.42	0.40	0.45	0.62	0.60	0.64
25	0.49	0.48	0.51	0.41	0.39	0.44	0.55	0.53	0.57
50	0.52	0.51	0.54	0.39	0.37	0.42	0.60	0.58	0.62
75	0.49	0.48	0.51	0.40	0.38	0.42	0.55	0.53	0.57
3 Months									
00	0.62	0.60	0.64	0.46	0.44	0.49	0.70	0.68	0.73
25	0.56	0.54	0.58	0.45	0.42	0.48	0.63	0.61	0.65
50	0.58	0.56	0.60	0.43	0.41	0.45	0.68	0.65	0.70
75	0.55	0.53	0.57	0.43	0.41	0.46	0.63	0.60	0.65

Table 3 shows the average size of a move from the popular endings. Although base rate moments are generally of 0.25%, the size of the change in retail interest rates is closer to

0.5%. Movements in base rates therefore have to pass a certain level in order to trigger an interest rate change.

Conversely from the probability of move shown in Table 2, it is 00 ending rates which generally appear to move by the largest amount, while 75 ending rates move by the smallest amount. Similar to the previous analysis, however, we find that moves down are of generally great magnitude, and that over longer horizons, there is a larger overall change in rates than at shorter horizons.

Table 4: Probability of a Rate Change given a Particular Change in the Base Rate

	Base Rate Change	Rate Ending	1 month		2 Months		3 Months	
			Up	Down	Up	Down	Up	Down
2005	-0.25, 0, 0	Popular	1.37	79.66	1.65	92.54	2.35	92.46
		Non-Popular	2.28	75.77	2.79	92.25	3.43	91.98
1998	+0.25, 0, 0	Popular	32.52	0.00	52.47	0.07	59.96	2.88
		Non-Popular	36.36	0.51	62.56	1.09	78.27	2.59
1994	+0.5, 0, 0	Popular	24.45	1.26	60.84	0.60	77.30	0.61
		Non-Popular	21.25	1.06	60.61	2.06	80.55	2.84
1993	-0.5, 0, 0	Popular	1.31	29.48	2.05	80.45	2.06	86.65
		Non-Popular	0.34	30.01	0.00	84.29	0.80	94.95
2000	+0.25, +0.25, 0	Popular	55.39	2.00	80.53	2.23	86.36	2.06
		Non-Popular	57.79	2.73	86.92	2.84	91.52	3.55
2001	-0.25, -0.25, 0	Popular	0.13	73.71	0.66	92.92	0.66	94.17
		Non-Popular	0.09	70.94	1.12	94.87	1.07	95.96
2002	0, 0, 0	Popular	1.01	0.72	1.31	1.97	0.77	3.22
		Non-Popular	0.40	1.56	1.12	3.48	1.61	4.91

The second column in Table 4 shows the shock dynamics over three months for which the transition probabilities are described. As an example, a -0.25, 0, 0 entry in this column signifies a Base Rate reduction of 0.25% in the first month followed by no further changes in the Base Rate over the next two months. Likewise a +0.25, +0.25, 0 entry signifies two consecutive months where the Base Rate increases by 0.25% followed in the third month by no further change. Although the dynamics are analysed in one particular period, as shown by the year in the first column, it is assumed these dynamics are typical of all such shock situations. Change probabilities are split according to whether the original rate ending was 00, 25, 50 or 75 which we call ‘popular’ while other endings are referred to as ‘non-popular’.

It should be noted that the November 1993 fall in the base rate by 0.5% is unusual in that the rate change announcement came towards the end of the month, on the 23rd, while the latest point for all other changes within the month is the 13th. Accordingly, the speed of adjustment appears overly slow, only because of publication lags and/or the fact other changes have over one and a half months for the change to be reflected in the interest tariffs, while this particular change only has just over a month. Further reassurance that the Base Rate acts as the main incentive for change is evidenced by the size of the directional probabilities: in all cases probabilities are significantly larger for change in the same direction as the change in the Base Rate.

The table provides some key insights in to the speed of reaction given both size and direction of a Base Rate change. Examining first the single change dynamics shown in the first 4 rows of the table it is clear to see that the probability of a change is generally much larger in earlier months when the rate is being reduced compared to when it is being increased. Over the full 3 months cumulatively, there is a larger overall probability of change (around 90%) for rate decreases compared with rate increases (80%). Given an increased incentive to change rates following consecutive changes in the Base Rate, the same observation that there is a lower incentive to move rates up compared with down is evident.

There isn't strong evidence in this table for consistently higher change probabilities if the rate is currently on at a non-popular ending, though there is some limited support for changes over longer-horizons. This finding is consistent with a profit maximising firm seeking to delay passing on costly rate increases to customers but immediately passing on cost saving reductions. Thus, in summary, there is significant asymmetry by firms in their reaction to Base Rate changes.

Error! Reference source not found. shows the size of probable moves for the various Base Rate events described above. Again these are not cumulative, with further correction within the 3-month horizon examined leading to a reduction in probability from one month to the next.

Table 5: Size of Rate Change given a Particular Change in the Base Rate

	Base Rate Change		1 month		2 Months		3 Months	
			Up	Down	Up	Down	Up	Down
2005	-0.25, 0, 0	Popular		0.27		0.28		0.30
		Non-Popular		0.29		0.29		0.30
1998	+0.25, 0, 0	Popular	0.30		0.31		0.34	
		Non-Popular	0.25		0.26		0.28	
1994	+0.5, 0, 0	Popular	0.47		0.38		0.37	
		Non-Popular	0.29		0.29		0.29	
1993	-0.5, 0, 0	Popular		0.48		0.52		0.55
		Non-Popular		0.29		0.49		0.48
2000	+0.25, +0.25, 0	Popular	0.26		0.40		0.43	
		Non-Popular	0.21		0.35		0.39	
2001	-0.25, -0.25, 0	Popular		0.30		0.44		0.45
		Non-Popular		0.31		0.49		0.50

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Table 7 are similar to Table 2 and Table 3 but instead of looking at the dynamics across 3 time horizons, instead consider a 1 month window restricted by the initial deposit balance. This will allow for the rate dynamics at the different interest rate tiers (a small, medium and large initial investment) to be examined and compared. The other difference from the previous tables is that in addition to tabulating moves from the 4 most popular endings, 00, 25, 50 and 75, we also group the moves in to those from popular and non-popular endings, and all moves, regardless of the initial ending state.

Table 6: Probability of a Move for Popular versus Non-Popular Endings for 3 Initial Deposit Balances

	All Moves				Moves Up				Moves Down		
	%	95% Confidence Interval			%	95% Confidence Interval			%	95% Confidence Interval	
		Lower	Upper			Lower	Upper			Lower	Upper
£500											
Popular	20.38	19.76	21.01		7.28	6.91	7.67		13.10	12.58	13.63
Non-Popular	19.63	19.09	20.17		7.83	7.51	8.14		11.80	11.36	12.22
Total	40.01				15.11				24.90		
00	20.29	19.22	21.37		6.48	5.96	7.01		13.81	12.93	14.68
25	19.74	18.51	21.13		7.94	7.25	8.72		11.80	10.79	12.78
50	19.20	18.03	20.39		6.76	6.17	7.37		12.45	11.60	13.33
75	22.88	21.59	24.24		8.48	7.71	9.30		14.41	13.39	15.48
£5,000											
Popular	21.08	20.55	21.60		7.87	7.56	8.18		13.22	12.82	13.62
Non-Popular	20.99	20.53	21.44		8.27	8.00	8.56		12.72	12.37	13.06
Total	42.07				16.14				25.93		
00	21.66	20.76	22.58		7.55	7.11	8.05		14.11	13.42	14.85
25	20.13	19.07	21.19		7.98	7.43	8.57		12.15	11.42	12.95
50	20.56	19.53	21.55		7.53	7.00	8.06		13.03	12.30	13.78
75	22.03	21.09	23.05		8.60	8.00	9.22		13.42	12.69	14.20
£50,000											
Popular	21.47	20.94	22.02		7.95	7.64	8.25		13.52	13.08	13.95
Non-Popular	21.51	21.02	22.00		8.47	8.18	8.77		13.04	12.70	13.39
Total	42.98				16.42				26.56		
00	21.84	20.89	22.81		7.52	7.06	7.95		14.32	13.60	15.03
25	19.67	18.60	20.81		7.85	7.30	8.41		11.82	11.14	12.56
50	21.44	20.38	22.56		7.81	7.16	8.58		13.63	12.88	14.40
75	23.07	22.01	24.18		8.85	8.27	9.46		14.22	13.42	15.14

Table 7: Size of a Move for Popular versus Non-Popular Endings for 3 Initial Deposit Balances

	£500								
	All Moves			Moves Up			Moves Down		
	Size	95% Confidence Interval Lower	95% Confidence Interval Upper	Size	95% Confidence Interval Lower	95% Confidence Interval Upper	Size	95% Confidence Interval Lower	95% Confidence Interval Upper
Popular	0.49	0.47	0.51	0.42	0.39	0.44	0.53	0.51	0.55
Non-Popular	0.44	0.43	0.46	0.35	0.33	0.37	0.51	0.49	0.52
00	0.51	0.48	0.53	0.42	0.38	0.46	0.55	0.52	0.58
25	0.48	0.45	0.51	0.45	0.39	0.51	0.50	0.47	0.53
50	0.49	0.46	0.52	0.40	0.35	0.46	0.54	0.51	0.57
75	0.47	0.44	0.49	0.40	0.35	0.45	0.51	0.48	0.53
	£5,000								
Popular	0.47	0.46	0.48	0.39	0.37	0.41	0.52	0.51	0.53
Non-Popular	0.43	0.42	0.44	0.34	0.32	0.35	0.49	0.48	0.50
00	0.49	0.47	0.51	0.38	0.35	0.41	0.55	0.53	0.57
25	0.45	0.43	0.47	0.37	0.34	0.40	0.50	0.48	0.53
50	0.48	0.46	0.50	0.40	0.37	0.43	0.53	0.51	0.55
75	0.46	0.44	0.48	0.41	0.37	0.45	0.49	0.47	0.51
	£50,000								
Popular	0.47	0.46	0.49	0.40	0.38	0.42	0.52	0.50	0.53
Non-Popular	0.43	0.42	0.44	0.33	0.31	0.34	0.49	0.48	0.50
00	0.50	0.48	0.52	0.42	0.38	0.45	0.55	0.53	0.57
25	0.46	0.44	0.49	0.43	0.39	0.47	0.49	0.47	0.51
50	0.47	0.45	0.48	0.36	0.34	0.39	0.52	0.50	0.55
75	0.45	0.43	0.47	0.40	0.36	0.44	0.48	0.46	0.51

All panels in Table 6 and likewise, all panels in Table 7 show a remarkably similar picture for the interest rate change dynamics. Further investigation, not reported here to converse space, shows a similar picture for other tiers of investment balances. It can therefore be concluded that the likelihood of change, and the size of change, is independent of the initial deposit balance, and so Table 2 and Table 3 provide a fair approximation of the dynamic process.

5. Conclusions

In this study we examine whether pricing points or convenient prices are associated with interest rate rigidity or alternatively whether more established and widely accepted menu cost explanations of rigidity appear more plausible as an explanation of rigidity. This question is examined in the context of retail banking using interest rates from a large proprietary dataset of retail deposit accounts. We report the interest rates appear to most frequently change from a relatively limited set of digits to similar form of digits. In particular we observe the use of fractions and whole numbers, associated with both pricing point and convenient pricing approaches having strong influences on interest rate setting in the market. Further change in interest rates is observed to be infrequent and associated with pricing point explanations rather than menu costs explanations in this market.

This is important to consider as how prices and interest rates form is central to many assumption of moderns economics. In micro economics much debate has focused on market efficiency and how well markets price certain assets; in macro economics the emphasis has been placed on how much nominal prices fail to adjust to changes in market conditions. This said, while pass through of prices has been used as a theoretical concept throughout economics (Alexandrov 2013) empirical evidence on this issue is still emergent. Moreover determining whether interest rates change infrequently and why this can occur is a question of significance for comprehending monetary policy more generally (Wolman 2007).

The implications of these findings are multifaceted. We suggest such findings contribute to growing literatures examining clustering and indicate the incidence of such practices may have in reducing pricing change. Second, current assumptions indicating the swift transmission of base rate changes into retail interest rates are slowed by the practices of using pricing points.

The operation and price setting in all financial markets and particularly banking has a direct influence on the operation and application of monetary policy. Reflecting this concern there has been a substantial literature examining the association between bank interest rates and the costs of funds. This literature assesses how bank interest rate setting is influenced by changes in the policy or base rate or the wholesale cost of funds, indicating how such monetary policy actions can eventually influence the supply of deposits. If the formation of prices or yields around certain digits has implications as to how prices may then change and respond to external factors, such as a changing policy or base rate then the past assumptions as to the transmission of monetary policy decisions may need to be revised.

Lastly, these practices are clearly acting against the interest of depositors with asymmetric responses to cost changes observed and depositors receiving lower levels of return as a result of this property. The reduction in clustering at these popular endings by around 20 per cent since 1989 could possibly be linked with the UK savings market becoming increasingly competitive. Financial institutions to effectively compete may have neededto attract financially savvy individuals, who will have good recall of rates and so demand rates which more accurately match with the costs of obtaining these funds faced by the financial institution. Alternatively, or perhaps additionally, consumers are becoming more financially aware and so the proportion of naïve customers has declined, and so financial institutions cannot exploit limited customer recall to the extent they once were able to do.

The observation of reducing clustering over time is also congruent with the finding of Kahn *et al* (1999) that the cost of funding is positively correlated with the level of clustering. The Bank of England base rate, the rate at which banks can borrow from the central bank, has had a general downward trajectory over the sample period. As such, following the reasoning of Kahn *et al* (1999) this reduction in the wholesale borrowing rate would suggest a reduction in clustering, which is indeed what we observe. What is perhaps surprising is that since 2009, when base rates hit 0.5%, there has actually been a small increase in the overall degree of clustering at 00, 25, 50 and 75 endings.

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