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Financial Innovations and the Interest Elasticity of Money Demand in the United Kingdom, 1963–2009

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Abstract

This paper empirically examines the relationship between financial innovations and interest elasticity of money demand in the UK. Contrary to most research work in this area, the results indicate that financial innovations and other deregulatory changes in financial market conditions after the 1980s have raised the interest elasticity of money demand, and this appears to support the Gurley-Shaw hypothesis. The evidence calls into question the relative efficacy of a monetary targeting approach in the conduct of monetary policy.

Key words: interest elasticity; money demand; financial innovations; Gurley-Shaw hypothesis; rolling regressions

JEL classification: C52; E41

1. Introduction

In recent years, the nature, form, and impact of financial innovation on financial markets has generated widespread attention from policymakers and researchers. For a full-blown discussion on the various aspects of financial innovation and an exhaustive list of reference, interested readers are referred to Frame and White (2004). Miller (1986) characterized the rapid rate of financial innovation over the past few decades as a financial revolution which appears to have tremendous impact on the progression and development of global financial markets, institutions, and the economy. For example, the recent global financial crisis of 2008, which emanated from the subprime loan markets and the derivative markets, have agonized the national and international authorities over the regulation of derivative markets. The crisis has generated tremendous interest into the nature, operation, working mechanism, regulation, and true significance regarding the exotic derivative products and markets, which represent one of many examples of financial innovations. Given the topical importance of the issue, there is a gap in the literature to assess the role, significance, and impact of financial innovation. After an

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exhaustive survey of literature, Frame and White (2004, p. 116) noted "Indeed, a broad descriptive literature that discusses recent financial innovations and that advances various hypothesis about them has proliferated. A striking feature of this literature, however, is the *relative dearth of empirical studies* that specifically test hypotheses or otherwise provide a quantitative analysis of financial innovation."

Therefore, in response to the claim of Frame and White (2004), in this article we empirically examine the relationship between financial innovation and the interest elasticity of money demand in the UK. The relationship between financial innovation and interest elasticity of money demand has generated widespread attention from policy makers and researchers (see Chowdhury, 1989; Darrat and Webb, 1986; and Hafer and Hein, 1984). This has been due to the following reasons. The first stems from the hypothesis, ascribed to Gurley and Shaw (1955, 1960), that financial innovations and other changes in the financial market would increase the interest elasticity of money demand. Gurley and Shaw contended that, as new interest-bearing substitutes of money are made available, money holdings become more sensitive to changes in interest rates, thus raising the interest elasticity of money demand (Chowdhury, 1989). Second, as a corollary of the Gurley-Shaw hypothesis, financial innovations call into question the conduct and efficacy of monetary policy. If interest elasticity of money demand increases due to financial innovations, then the predictability and stability of the relationship between monetary aggregates and ultimate goal variables related to output, prices, and interest rates as predicted in the conventional money demand functions are weakened. Therefore, any support for the Gurley-Shaw thesis would suggest that policymakers and monetary authorities should de-emphasize an explicit monetary targeting in the conduct of monetary policy. Given that the monetary authorities now conduct monetary policy by adopting an explicit long-run inflation target, monetary targeting still remains, at least in intention, one important indicator of monetary policy. Therefore, the study has important implication to researchers and policymakers.

Several empirical studies have investigated the relationship between financial innovations and interest elasticity of money demand. Cagan and Schwartz (1975) and Hafer and Hein (1984) used quarterly US data to investigate the issue. Chowdhury (1989) and Darrat and Webb (1986) examined the issue utilizing annual data from Canada and India for the periods 1934–1986 and 1937–1982, respectively. Interestingly, none of the studies found that the interest elasticity of money demand increased over time, which appears to reject the Gurley-Shaw hypothesis. Despite the theoretical and operational significance of this issue, the results are at odds with recent empirical findings, which suggest that significant financial innovations have caused instability in the money demand relationship in the US (see, for example, Goldfeld, 1976; Garcia and Pak, 1979) and in the UK (see, for example, Goodhart, 1989; Arestis et al. 1992; and references therein).

The main purpose of this paper therefore is to empirically re-examine the Gurley-Shaw hypothesis for the UK using quarterly data from 1963Q1 to 2009Q1. Although the most dramatic changes in the financial market and payment mechanism have occurred during the decades since the late 1970s, most previous studies are heavily centered on observations in the pre-deregulation and pre-innovation period. For example, the sample period of Cagan and Schwartz (1975) spans the periods 1921Q1–1931Q4 and 1954Q1–1971Q4, while Hafer and Hein’s (1984) sample period covers 1915Q1–1979Q4. Unlike previous research, we estimate interest elasticities using more recent data. Contrary to earlier research in this area, the results in this paper indicate that the interest elasticity of money demand has increased during the post-deregulation and post-innovation period, a finding that accords well with the Gurley-Shaw hypothesis.

During the late 1970s and throughout the 1980s, financial markets in the UK witnessed a wave of financial deregulation and innovations on several fronts. For a detailed account of financial innovations and their impact in the UK financial market, see Gowland (1991), Mullineux (1994), and Podolski (1986). First, the official authorities initiated various measures of deregulation in the financial market; these included removal of foreign exchange controls (1979), abolition of direct monetary controls on banks (1980), the legislation of the Financial Services Act, the Building Societies Act of 1986 and 1997, and stock exchange deregulation (1986). Second, financial institutions started to offer market-related interest rates on sight deposits in the early 1980s which had previously earned zero interest. Third, following financial deregulation and technological improvement, many new forms of financial services and instruments have been introduced, and new operational techniques within financial institutions and markets have evolved. These financial innovations include new payment systems, home banking, internet banking, personal equity plans (PEPs), tax exempt special saving accounts (TESSAs), and individual savings accounts (ISAs).

Given this background, this study provides an illuminating opportunity to examine whether the interest elasticity of money demand exhibits any upward drift in the UK during the recent years of financial market deregulation and innovations. The paper is organized as follows. Section 2 presents the model and empirical results. Section 3 contains the summary and conclusion.

2. The Model and Empirical Results

We specify a conventional money demand function to test the Gurley-Shaw hypothesis that financial innovations produce secular upward shift in the interest elasticity of money demand in the UK:

$$\ln(m/p)_t = \delta_0 + \delta_1 \ln y_t + \delta_2 \ln r_t + \delta_3 \ln(m/p)_{t-1} + \varepsilon_t \,. \tag{1}$$

The model explains the demand for real money balances (m/p) as a function of income (y), and the interest rate (r) while allowing for a partial adjustment of actual money balances to desired money balances, signified by the lagged response variable $(m/p)_{t-1}$. This specification has been chosen following the precedence of previous studies such as Chowdhury (1989), Darrat and Webb (1986), and Hafer and

Hein (1984). Chowdhury (1989), Darrat and Webb (1986) and Hafer and Hein (1984) have used narrow money stock, income, and short-term interest rates as proxies of money balance, scale, and opportunity cost variables, respectively. Since the objective of our research is neither to conduct a specification search nor to resolve the missing money puzzles of the money demand function, this "state of the art" specification will enable us to compare our results with those of other countries in this area of research.

There is a controversy regarding the relative choice between narrow and broad monetary aggregates as a response variable in the money demand equation. Studies of Chowdhury (1989), Darrat and Webb (1986), and Hafer and Hein (1984) have used narrow measures of money stock, such as M1. Hetzel and Mehra (1989) used the M1 measure of money stock in the case of the US money demand function. In a comparable study using UK data, Arestis et al. (1992) and Hendry and Ericsson (1992) have employed total M1, which includes both interest-bearing and non-interest-bearing sight deposits. Arestis et al. (1992) have noted that the proliferation and rapid growth of interest-bearing sight deposits during the early and mid-1980s, respectively, have caused the standard money demand relationship to underestimate M1 for the UK in the 1980s. In contrast, much recent money demand research has concentrated on broader monetary aggregates such as M2 in the US, M3 in Germany, and M3 and M4 in the UK as researchers have recognized the substitutability between money and "near money" assets (see for example Taylor, 1987; and Mariscal et al. 1995). With the advent of market liberalization, financial innovation, and increasing competition, there have been frequent portfolio shifts between narrow money and the near money substitutes in the broader monetary aggregates. For example, Arestis et al. (1992) reported that the ratio of interest bearing sight deposits to time deposits has increased from around 10% in 1981 to 77% in 1987 with the proliferation of interest bearing sight deposits. Using a broader measure of monetary aggregates as a response variable tends to mask this portfolio substitution behavior of market participants away from non-interest-bearing M1 to interest-bearing M1 and therefore could give an undue perception of money demand stability. Given the implicit focus of the Gurley-Shaw hypothesis on narrower monetary aggregates, to compare with the experiences of other countries, and to purge out the effect of underestimation induced by the interest-bearing sight deposits of the 1980s, we use non-interest-bearing M1 as our measure of money stock. This measure comprises currency holdings of the public and banks plus the UK private sector non-interest-bearing sterling deposits with bank. Interested readers are referred to Arestis et al. (1992) and Hendry and Ericsson (1992) for interest-bearing M1 and to Mariscal et al. (1995) and Taylor (1987) for M4 and M3 measures of money stock, although these studies have not examined the upward trend of interest elasticity in the money demand function using the rolling regression framework.

The empirical counterparts to the model variables are as follows: income is measured by real GDP with the 1995 as the base year. Monetary aggregates are the non-interest-bearing M1 measure of the Bank of England. The three-month treasury bill rate (TBR) proxies the short-term interest rates. The price level is represented by the GDP deflator (1995=100). Data on M1, GDP, GDP deflator, and treasury bill yield over the period 1963Q1–2009Q1 have been obtained from the Office for National Statistics (formerly Central Statistics Office). The Bank of England and the Office for National Statistics published the M1 data up to 1990Q3. We have constructed the non-interest-bearing M1 series using the Bank of England definition: notes and coin holdings of the public and bank plus the UK private sector non-interest-bearing sterling deposits of banks, minus 60% of transit items.

The data have been checked for stationarity using the augmented Dickey-Fuller (ADF) unit root test. All variables are expressed in logs. The number of augmentation terms in the ADF regression was determined using Akaike's information criterion (AIC), up to an eight-quarter lag, and serial correlation of residuals. Table 1 presents the ADF t-statistics and the optimum lag length of ADF regression. The results of the ADF test in Table 1 indicate that all three variables are non-stationary at level but stationary in first difference form.

Table 1. Unit Root Test Results

Variable	L		Δ	
	t_μ	t_τ	t_μ	t_τ
m/p	–1.337 (k = 4)	–0.380 (k = 4)	–3.913 (k = 4)	–4.349 (k = 4)
y	–0.643 (k = 3)	–2.717 (k = 3)	–5.513 (k = 2)	–5.507 (k = 2)
r	–0.912 (k = 1)	–1.549 (k = 1)	–9.061 (k = 0)	–9.319 (k = 0)

Notes: L and Δ denote the level and first difference of a variable, respectively, and t_μ and t_τ are t-statistics based on ADF regressions with allowance for a constant and trend, respectively. Lag lengths are in parentheses. 5% critical values are –2.88 and –3.44 for constant and trend, respectively.

In the next step, the data series have been further checked using the Johansen and Juselius (1990) (JJ hereafter) maximum likelihood procedure to test for cointegration. The main advantage of the JJ method is that it indicates the presence of the number of cointegrating vectors and provides more reliable estimates of the long-run parameters. Gonzalo (1994), Hargreaves (1994), and Cheung and Lai (1993) have provided good discussions on the desirable properties of Johansen's estimators. The Johansen vector autoregressive (VAR) model is specified with an intercept term as its deterministic component. This specification will generate deterministic trends in the level of the variables when the long-run multiplier matrix is rank deficient and variables are I(1) (see Pesaran and Pesaran 1997). Moreover, the joint significance of an intercept term in each of the equations of the VAR model is tested by a likelihood ratio test. The calculated $\chi^2_{(3)}$ -statistic is found to be 16.07 (p-value 0.001), indicating that the hypothesis that the intercepts are jointly equal to zero is decisively rejected. The number of lags in the Johansen VAR model was determined using the AIC up to eight quarter lags and the serial correlation of residuals. Use of the maximum AIC criterion in conjunction with the inspection of serial correlation of residuals of individual equations suggested a lag length of eight. Moreover, as Hargreaves (1994) has suggested that Johansen's maximum likelihood procedure provides relatively robust results with an overparameterized model, the optimal lag length of the VAR model was chosen to be eight.

Results of Johansen's eigenvalue and trace tests are presented in the upper panel of Table 2 and indicate that there exists at least one cointegrating relationship in the trivariate VAR system since the calculated test statistics exceed the 95% critical values which hypothesized the existence of a zero cointegrating vector. The results tend to suggest that there exists at least one stationary relationship between real money stock, income, and interest rates. Given that there are $n-r$ common trends within the system, we can conclude that there exist two common trends within the vector.

Table 2. Johansen Tests for Cointegrating Relationships between Real Money Balance, Income, and Interest Rates

H_0:	H_1:	Test statistics		95% critical value	
		Max Eigenvalue	**Trace**	**Max Eigenvalue**	**Trace**
$r=0$	$r>0$	27.61*	40.07*	22.04	34.87
$r\le 1$	$r=2$	7.78	12.57	15.87	20.18
$r\le 3$	$r=3$	4.67	4.67	9.16	9.16

Series	Max eigenvalue statistics			Trace statistics		
end	$r=0$	$r\le 1$	$r\le 2$	$r=0$	$r\le 0$	$r\le 2$
1979Q4	23.72*	17.94*	5.41	47.09*	23.36*	5.91
1986Q4	24.17*	16.91*	5.41	45.77*	21.60*	4.69
1989Q4	29.74*	16.80*	5.11	51.67*	21.92*	5.11
1992Q4	29.30*	7.13	4.95	41.39*	12.08	4.95
1998Q4	33.58*	7.88	4.92	46.39*	12.80	4.92
2001Q4	23.40*	6.22	4.04	33.66+	10.26	4.04
2004Q4	32.21*	7.48	4.04	43.74*	11.57	4.04
2007Q4	32.11*	6.40	4.59	43.11*	11.00	4.59
2009Q1	27.61*	7.78	4.67	40.07*	12.45	4.67

Notes: r indicates the number of cointegrating relationships; * and + indicate rejection at 95% and 90% critical values, respectively. All series begin in 1963Q1.

We have also performed Johansen's maximum likelihood procedure in a recursive framework as suggested by Hansen and Johansen (1993). In view of the large sample requirements of the JJ procedure, the initial period for the recursive estimation is specified up to 1979Q4. Note that in the subsequent discussion, 1979Q4 has been identified as the turning point of financial market deregulation and innovation. Then the eigenvalue and trace test statistics are estimated recursively over the subperiods 1963Q1–1986Q4, 1963Q1–1989Q4, 1963Q1–1992Q4, 1963Q1–1998Q4, 1963Q1–2001Q4, 1963Q1–2004Q4, 1963Q1–2007Q4, and 1963Q1–2009Q1. The lower panel in Table 2 reports the results from recursive estimation. The existence of cointegration is again evident over various subperiods.

The finding of cointegration among these macroeconomic variables has several implications. First, consistent with economic theory, this finding indicates that real money balance, income, and interest rates have a long-run equilibrium relationship. Second, the evidence of cointegration also rules out the possibility of spurious correlations and Granger noncausality between real money balance, income and interest rate variables.

Both the unit root and cointegration tests indicate that the variables real money balances, income and interest rate are I(1) and cointegrated, respectively. Under the conditions described in Engle and Granger (1987), Sims et al. (1990), Stock (1987), and Wallace and Choudhry (1995), the asymptotic distributions of t-, F-, and DW-statistics are valid even when the data set consists of non-stationary cointegrated series. We therefore estimate regressions using the log level of variables to obtain direct elasticity estimates.

To ascertain the temporal behavior of the interest elasticity of money demand, a rolling regression technique was employed. First, we begin by estimating the money demand equation over subperiods 1963Q2–1979Q4, 1980Q1–1998Q4, and 1999Q1–2009Q1, identifying 1979Q4 as a turning point of financial market deregulation and innovation. The cut-off point appears to be reasonable since UK financial innovation accelerated in the forms of deregulation-induced, market-induced, and product innovations following 1979Q4. The split of the sample into two broad subperiods will provide us with an overall indication of the effects of financial innovation on the interest elasticity of money demand. In order to examine this process more closely, we further split the sample in smaller subperiods. In the next step, the money demand equation was estimated over subperiods 1963Q2–1970Q4, 1971Q1–1979Q4, 1980Q1–1989Q4, and 1990Q1–1998Q4. Finally, we split the sample into much smaller subperiods while keeping a reasonable number of observations to ensure reliable parameter estimates. More specifically, the estimation begins with an initial six-year subperiod ranging from 1963Q2 to 1968Q4. This initial sample is then increased in subsequent estimation by adding six years to the start and end points, thereby generating subperiods 1963Q2–1968Q4, 1969Q1–1974Q4, 1975Q1–1980Q4, 1981Q1–1986Q4, 1987Q1–1992Q4, 1991Q1–1998Q4, 1999Q1–2004Q4, and 2003Q1–2009Q4.

Equation (1) is estimated using the Cochrane-Orcutt method to obtain efficient parameter estimates. The regression results based on the rolling regression method are presented in Table 3. It is evident from the table that all the regressions exhibit an excellent fit, as measured by high values of adjusted R^2 and small standard errors. Durbin's h-statistic indicates the absence of first-order serial correlation in the residuals. We also compute an alternative to Durbin's h-statistic over the sample period 1990Q1–1998Q4 and 1991Q1–1998Q4, when $TVar(\delta_3) > 1$. As suggested by Durbin, we estimate an equation of the form $\varepsilon_t = \alpha + \rho\varepsilon_{t-1} + \delta_1 Y_t + \delta_2 r_t + \delta_3 (m/p)_{t-1} + u_t$, where ε_t denotes residuals from (1). The regression is then run on all variables with $T-1$ observations after discarding the first observation. The resulting statistic is t-distributed to test the null hypothesis that ρ is not significantly different from zero (see Pindyck and Rubinfeld, 1981). We find that the t-statistics are –0.318 and –0.082 for the subperiods 1990Q1–

1998Q4 and 1991Q1–1998Q4, respectively, and therefore do not reject the null hypothesis of no serial correlation. The estimated equations in general appear to validate the diagnostic tests of higher-order serial correlation, functional-form misspecification, and heteroscedasticity in most cases.

All coefficients have the theoretically expected sign, and, in most cases, are statistically significant at a reasonable significance level.

Table 3. AR1 Estimates of the Money Demand Function

Coefficient	Estimation Period						
	1963Q2–1979Q4	1980Q1–1998Q4	1999Q2–2009Q1	1963Q2–1970Q4	1971Q1–1979Q4	1980Q1–1989Q4	1990Q1–1998Q4
y_t	0.705	0.511	0.677	0.408	0.762	0.648	2.046
	(3.082)	(1.992)	(3.122)	(1.047)	(2.366)	(1.850)	(2.921)
	[0.003]	[0.050]	[0.0347]	[0.305]	[0.0248]	[0.0731]	[0.0066]
r_t	–0.0551	–0.0824	–0.0874	–0.048	–0.057	–0.1014	–0.0993
	(–5.091)	(–4.690)	(–3.346)	(–2.167)	(–3.507)	(–4.090)	(–3.094)
	[0.000003]	[0.00001]	[0.0018]	[0.0403]	[0.0014]	[0.00025]	[0.043]
$(m/p)_{t-1}$	0.826	0.855	0.381	0.756	0.825	0.583	0.302
	(13.81)	(12.10)	(2.086)	(5.173)	(8.512)	(4.333)	(1.687)
	[0.000]	[0.000]	[0.0439]	[0.00002]	[0.000]	[0.00012]	[0.102]
R^2	0.950	0.871	0.824	0.800	0.938	0.883	0.748
h	0.322	0.057	–1.132+	0.638	0.361	0.007	-0.318^{+}
SE	0.022	0.030	0.047	0.014	0.029	0.023	0.031
$LM : \chi^2_{(3)}$	5.871	4.739	3.061	3.815	5.657	1.382	4.68
	(0.118)	(0.191)	(0.382)	(0.282)	(0.129)	(0.709)	(0.169)
$RESET : \chi^2_{(1)}$	0.208	0.0937	0.336	3.480	0.295	1.030	0.011
	(0.648)	(0.759)	(0.561)	(0.060)	(0.586)	(0.310)	(0.915)
$HET : \chi^2_{(1)}$	0.0039	0.0078	0.083	0.0578	0.1870	0.2414	0.733
	(0.949)	(0.929)	(0.772)	(0.809)	(0.665)	(0.623)	(0.391)

As the sub-sample period approaches more recent years of financial innovation, the parameter estimates related to the interest rate variable are expected to exhibit an upward shift to validate the Gurley-Shaw thesis. A comparison of (1) over the subperiods 1963Q2–1979Q4, 1980Q1–1998Q4, and 1999Q1–2009Q1 clearly indicates that the coefficient related to the interest rate variable exhibits a remarkable upward shift from –0.055 to –0.082, and –0.087 in the post-1980s period.

Next, we look at other subperiods. The short-run interest elasticities exhibit a substantial degree of stability prior to the pre-deregulation and pre-innovation period, where the values range from –0.048 to –0.057 in the subperiods 1963Q2–1970Q4 and 1971Q1–1979Q4, respectively. The interest elasticities, however, tend to increase from a level of –0.057 to –0.1014 and –0.0993 during the 1980Q1–1989Q4 and 1990Q1–1998Q4 subperiods, respectively. The relative stability is also evident in the smaller subperiods where the values ranges from –0.0445 to –0.0613 prior to 1980. However, the absolute value of interest elasticities tends to increase persistently from –0.0689 to –0.1109 to –0.108 to and –0.137, during the last four subperiods (1981Q1–1986Q4, 1987Q1–1992Q4, 1991Q1–1998Q4, and 2003Q1–2009Q1, respectively). It is interesting to note that the results do show considerable instability in the income and lagged response variable terms in the subperiods 1980Q1–1989Q4 and 1990Q1–1998Q4, respectively. Thus the results under the alternative specification of different subperiods consistently indicate that the short-run interest elasticity of money demand exhibits a secular increase during the post-deregulation and post-innovation periods after 1980. This empirical finding appears to support the Gurley-Shaw hypothesis that financial innovations in the late 1970s and throughout the 1980s in the UK financial market have significantly altered the sensitivity of holding real money balances to changes in interest rates. Moreover, the results are also in sharp contrast with previous research findings in this area which feature data from Canada, India, and the US.

Table 3. AR1 Estimates of the Money Demand Function (continued)

Coefficient	Estimation Period							
	1963Q2–1968Q4	**1969Q1–1974Q4**	**1975Q1–1980Q4**	**1981Q1–1986Q4**	**1987Q1–1992Q4**	**1990Q1–1998Q4**	**1999Q1–2004Q4**	**2003Q1–2009Q1**
y_t	0.419	0.435	1.019	1.170	0.813	2.50	3.261	1.617
	(1.041)	(2.276)	(2.002)	(2.009)	(1.419)	(2.217)	(1.532)	(3.740)
	[0.313]	[0.036]	[0.0614]	[0.0606]	[0.173]	[0.0433]	[0.1437]	[0.0012]
r_t	–0.0445	–0.0613	–0.0473	–0.0689	–0.1109	–0.108	–0.042	–0.137
	(–1.922)	(–6.577)	(–1.920)	(–2.665)	(–3.324)	(–2.910)	(–0.646)	(–4.073)
	[0.0724]	[0.000004]	[0.0717]	[0.0162]	[0.004]	[0.0074]	[0.5266]	[0.00054]
$(m/p)_{t-1}$	0.573	0.807	0.562	0.593	0.679	0.258	0.633	–0.049
	(2.792)	(9.155)	(3.386)	(3.614)	(4.484)	(1.294)	(3.918)	(0.170)
	[0.0130]	[0.000]	[0.0035]	[0.0021]	[0.0003]	[0.207]	[0.0011]	[0.8659]
R^2	0.406	0.870	0.736	0.797	0.964	0.755	0.664	0.784
h	0.276	0.057	0.168	0.302	0.309	–0.082+	0.085	–1.371+
SE	0.012	0.0169	0.031	0.0212	0.0245	0.032	0.042	0.045
$LM:\chi^2_{(2)}$	0.289	0.249	3.634	0.769	7.936	0.272	4.064	1.827
	(0.865)	(0.882)	(0.162)	(0.680)	(0.018)	(0.872)	(0.254)	(0.608)
$RESET:\chi^2_{(1)}$	1.987	1.287	0.217	0.166	0.642	0.393	0.100	1.115
	(0.158)	(0.256)	(0.641)	(0.683)	(0.422)	(0.530)	(0.751)	(0.290)
$HET:\chi^2_{(1)}$	0.200	0.564	0.093	0.00012	0.113	0.826	0.430	0.0067
	(0.654)	(0.452)	(0.760)	(0.990)	(0.735)	(0.363)	(0.511)	(0.934)

Notes: The regressions include a time trend and constant. t-statistics are in parentheses and p-values are in brackets. R^2 is the coefficient of determination adjusted for the degrees of freedom; SE signifies the standard error of the regression and h is Durbin's h-statistic. The $LM:\chi^2_p$ statistic tests the *p*-th order serial correlation of residuals. *RESET* and *HET* are test statistics for the appropriateness of the functional form and conditional heteroscedasticity of residuals.

One important reason underlying this upward trend in interest elasticities is the proliferation of interest-bearing sight deposits, which is one of many financial innovations. Arestis et al. (1992) have noted that the payment of interest on sight deposits was introduced in 1981 and from the end of 1983 there was a rapid growth of interest-bearing sight deposits. As individuals learn gradually about interest rates available on new products, a full-blown and highly discernible effect has been witnessed toward the end of 1983 and beginning of 1984, with a peak occurring sometime in the mid-1980s. However, the persistent upward trend is not a one-off phenomenon but rather the outcome of increased financial market liberalization, innovations, and competition. As the economy is increasingly exposed to financial liberalization, competition, and innovations, the nature and strength of the relationship between the real money balance and interest rates became more sensitive and the interest elasticities of money demand have been increased.

The above findings are further corroborated using the Farley and Hinich (1970) testing procedure. Following Darrat and Webb (1986), a new variable, expressed as a product of time trend and interest rates, $TInr_t$, is created, treating the interest rate variable as a linear function of time trend (T) and the resulting variable is added to the basic equation. The augmented equation is estimated with a constant. Under this technique, a significant coefficient related to the variable, $TInr_t$ would suggest the presence of a parametric shift in the interest elasticity of money demand. The test results are presented in Table 4. It is evident from the table that the coefficient related to the variable $TInr_t$ is statistically significant in most regressions related to subperiods 1975Q1–1980Q4, 1981Q1–1986Q4, 1987Q1–1992Q4, 1991Q1–1998Q4, and 1999Q1–2009Q4. This finding again reaffirms the upward drift of the interest rate variable in the money demand function.

Table 4. Farley and Hinich's Testing Procedure for Parameter Stability

Estimation Period	$TInr_t$	**t-statistic**	**p-value**
1963Q2–1968Q4	–0.00094	–0.876	0.3939
1969Q1–1974Q4	–0.00085	–1.637	0.1198
1975Q1–1980Q4	–0.00285	–2.280	0.0357
1981Q1–1986Q4	–0.00357	–2.749	0.0136
1987Q1–1992Q4	–0.00469	–2.848	0.0111
1991Q1–1998Q4	–0.00496	–2.110	0.0449
1999Q1–2009Q1	–0.00290	–1.607	0.1171

Finally, we have also used M4 to ascertain the sensitivity of the results to the choice of broader monetary aggregates as a response variable. M4 provides a very broad measure of money, which includes notes, coins, and sterling deposit liabilities of all UK banks and building societies (including sterling certificate of deposits) to the private sector. The components of M4 are suitable for "cash management" purposes for households and firms for transaction, precautionary, and asset demand purposes. Since M4 combines a wide range of money and near money substitutes, changes in interest rates in a particular component trigger portfolio shifts among near money assets and other components in broad money, including non-monetary assets. Moreover, both clearing banks and building societies are the prime providers of mortgage loans to the private sector. Induced by financial market deregulation, the entrance of clearing banks to the mortgage market brought a noticeable increase in competition and eliminated credit rationing in the mortgage market. Ryding (1990) and Wheeler and Chowdhury (1993) have contended that financial market deregulation and innovation significantly altered the structure of the transmission mechanism of monetary policy by reducing the power of the cost of capital and credit-rationing channels. For example, during the economic downturn of the late 1980s and early 1990s, the UK housing and mortgage market activities were less sensitive to interest rates combined with negative equity, repossessions, and a large volume of unsold residential property. The explanatory power of interest rates tended to evaporate in the post-deregulation period (see Hasan and Taghavi, 2002). Using M4 as a response variable in the money demand function would exhibit differential effects of interest sensitivity of money demand. Given this background, we have tested the interest elasticity of M4 as a function of both absolute and relative interest rates. In the preceding discussion, a representative interest rate was regarded as a measure of absolute interest rate, while estimating equation (1) using narrow money stock as response variable. Following Mariscal et al. (1995), the relative interest rate variable is defined as an excess return of a non-monetary asset over the own rate of return on M4:

$$SPREAD = RNM - ROWN\ , \tag{2}$$

where the variables RNM and $ROWN$ are defined as return of non-monetary asset and own rate of return on M4. $ROWN$ is defined as a weighted average of interest rates of various interest-bearing components of M4:

$$ROWN = R_{ib}(IBS/M4) + R_{td}(TD/M4) + R_{cd}(CD/M4) + R_{bsd}(BSD/M4), \tag{3}$$

where IBS, TD, CD, and BSD denote interest-bearing bank sight deposits, bank time deposits, bank and building society certificates of deposits, and building society shares and deposits, respectively, and R_{ib}, R_{td}, R_{cd}, and R_{bsd} are the corresponding rates of interest.

RNM is proxied by the redemption yield on the long-dated (20-year) government bond. Consistent data to construct a weighted average of own rate of return on M4 in (2) are unavailable over the sample period. Furthermore, Mariscal et al. (1995) and others have suggested using a representative rate instead of using a combination of interest rates to avoid the problem of multicollinearity. Therefore, we have used a representative deposit rate as a proxy of own rate of return on M4. Consistent and long-spanning data on deposit rates were extracted from International Financial Statistics (IFS), published by the International Monetary Fund. However, the data series of the representative deposit rate were discontinued in the IFS after the year 2000, which restricts our ability to estimate the regression covering the sample period up to 2009Q1. Data on M4 and long-dated government bond yields have been obtained from the Office for National Statistics.

Unit root tests indicate that the variables broad money, government bond yield, and deposit rate are I(1). The cointegration test result shows that the variables in the money demand function using M4 have one cointegration relationship over the sample period. First, we have regressed the real M4 balance on the short-term interest rate variable as a measure of the absolute interest rate over the subperiods 1963Q2–1979Q4, 1980Q1–1998Q4, and 1980Q1–2009Q1. The results are reported in the second, third, and fourth columns of Table 5(a). In the next step, we have regressed real M4 on the representative deposit rate and the long-term bond yield over the pre- and post-deregulation subperiods 1963Q2–1979Q4 and 1980Q1–1998Q4, respectively. The results are reported in the fifth and sixth columns of Table 5(a). Finally, the real M4 balance was regressed on the SPREAD variable, which proxied the relative interest rate variable over the pre- and post-deregulation subperiods. The results are presented in the last two columns of Table 5(a).

Table 5(a). Parameter Estimates of the Money Demand Function using M4

Coefficient	Estimation Period						
	1963Q2-1979Q4	**1980Q1-1998Q4**	**1980Q1-2009Q1**	**1963Q1-1979Q4**	**1981Q1-1998Q4**	**1963Q1-1979Q4**	**1980Q1-1998Q4**
y_t	0.416	0.246	0.135	0.404	0.264	0.295	0.272
	(2.639)	(1.821)	(1.546)	(2.557)	(2.174)	(1.760)	(2.247)
	[0.010]	[0.073]	[0.1248]	[0.0131]	[0.033]	[0.083]	(0.027)
r_t	–0.038	–0.005	–0.0047				
	(–3.885)	(–0.433)	(–0.753)				
	[0.0003]	[0.665]	[0.452]				
ROWN				–0.0227	–0.0045		
				(–3.292)	(–0.578)		
				[0.0017]	[0.565]		
RNM				–0.0638	–0.00051		
				(–2.772)	(–0.028)		
				[0.0074]	[0.977]		
SPREAD						0.0043	0.00056
						(2.120)	(0.621)
						[0.038]	[0.536]
$(m/p)_{t-1}$	0.959	0.883	0.975	1.017	0.911	0.853	0.905
	(24.78)	(12.98)	(38.80)	(26.06)	(14.67)	(4.151)	(16.38)
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.0001]	[0.000]
R^2	0.992	0.998	0.999	0.993	0.998	0.991	0.998
h	0.119	0.362	0.640	0.082	0.378	-0.235^{+}	0.392
SE	0.014	0.011	0.012	0.013	0.011	0.014	0.011
$LM:\chi^2_{(3)}$	2.975	8.922	9.619	3.400	11.00	1.372	10.36
	(0.395)	(0.030)	(0.022)	(0.339)	(0.011)	(0.712)	(0.015)
$RESET:\chi^2_{(1)}$	4.00	14.03	3.208	2.439	11.84	2.514	11.44
	(0.135)	(0.000)	(0.073)	(0.118)	(0.000)	(0.112)	(0.007)
$HET:\chi^2_{(1)}$	5.841	0.047	0.047	3.080	0.074	0.627	0.081
	(0.004)	(0.827)	(0.828)	(0.079)	(0.784)	(0.421)	(0.775)

Table 5(b). Parameter Estimates of the Money Demand Function using M4 (continued)

Coefficient	Estimation Period					
	1980Q1-1987Q3	1987Q4-1998Q4	1980Q1-1987Q3	1987Q4-1998Q4	1980Q1-1987Q3	1987Q4-1998Q4
y_t	0.191	0.190	0.093	0.288	0.217	0.265
	(0.556)	(1.748)	(0.456)	(3.887)	(0.699)	(3.322)
	[0.582]	[0.0883]	[0.652]	[0.0004]	[0.491]	[0.0019]
r_t	0.0055	0.017				
	(0.309)	(1.015)				
	[0.759]	[0.3160]				
ROWN			–0.0014	0.0021		
			(–0.1409)	(0.1868)		
			[0.889]	[0.8528]		
RNM			0.038	0.0135		
			(1.552)	(0.7253)		
			[0.1337]	[0.4727]		
SPREAD					0.00026	–0.00031
					(0.226)	(–0.2326)
					[0.822]	[0.8173]
$(m/p)_{t-1}$	0.442	0.760	0.614	0.820	0.438	0.841
	(0.780)	(6.898)	(2.570)	(7.698)	(0.902)	(11.812)
	[0.442]	[0.000]	[0.0168]	[0.000]	[0.375]	[0.000]
R^2	0.996	0.993	0.997	0.993	0.996	0.993
h	–0.145$^+$	0.243	0.0029$^+$	0.171	–0.174$^+$	0.120
SE	0.010	0.0099	0.0099	0.010	0.010	0.010
$LM : \chi^2_{(2)}$	0.706	1.384	0.040	3.154	0.727	2.181
	(0.702)	(0.500)	(0.980)	(0.206)	(0.694)	(0.335)
$RESET : \chi^2_{(1)}$	4.381	0.255	0.802	0.344	4.362	0.830
	(0.036)	(0.613)	(0.370)	(0.557)	(0.0367)	(0.362)
$HET : \chi^2_{(1)}$	0.147	0.104	0.0092	0.0068	0.244	0.030
	(0.700)	(0.746)	(0.923)	(0.934)	(0.621)	(0.860)

Notes: The regressions include a time trend and constant. t-statistics are in parentheses and p-values are in brackets. R^2 is the coefficient of determination adjusted for the degrees of freedom; SE signifies the standard error of the regression and h is Durbin's h-statistic. The $LM : \chi^2_p$ statistic tests the *p*-th order serial correlation of residuals. *RESET* and *HET* are test statistics for the appropriateness of the functional form and conditional heteroscedasticity of residuals.

$^+$'t' statistic to test serial correlation.

Turning to the estimates in the second and third columns, we find that interest rate and income variables are statistically significant during the 1963Q2–1979Q4 subperiod, while the interest rate variable is not statistically significant in the 1980Q1–1998Q4 subperiod. The results in the fifth and sixth columns also indicate that the deposit rate and long-bond yield variables are significantly negative in the pre-deregulation period while they are not statistically significant in the post-deregulation period. Finally the results in the last two columns are also supportive of the statistical significance of the relative interest rate variable only in the pre-deregulation period. Therefore, it is evident that using broad money (M4) as a response variable in the money demand function exhibits a different pattern of interest rate sensitivities in the pre- and post-deregulation subperiods due to the portfolio substitution behavior of market participants and deregulation-induced elimination of credit rationing (channel) in the financial markets. Furthermore, Mariscal et al. (1995) noted that the weighted average of own rates of return of the broader monetary aggregate would tend to rise relative to the rates of return of other non-monetary assets with the advent of financial market deregulation and innovation. The secular increase in money's own rate corresponds to a secular decline in the opportunity cost of holding money, which would be likely to narrow the differential between these two competing rates of return. The lack of significance might be attributed to the nonstationary movements of those returns' differential.

It is also evident in Table 5(a) that the money demand equation estimated over the post-deregulation subperiod under alternative specifications of the interest rate variable exhibits higher order serial correlation and misspecification error. Careful examination of the data series relating to the response variable (i.e., broad money stock) shows that extreme observations exist in the series over the 1981Q1–1987Q3 subperiod. These extreme observations are induced by the deregulatory changes as well as the unbridled monetary growth during that period. To ameliorate this diagnostic failure induced by a shift in the process-generating mechanism, therefore, we have re-estimated the money demand regression over the 1980Q1–1987Q3 and 1987Q4–1998Q4 subperiods. The results are presented in Table 5(b). Interestingly, the regression results now validate the diagnostic tests of serial correlation, heteroscedasticity, and misspecification error in most cases. However, the interest rate variable in the money demand function is not significant across post-deregulation subperiods and alternative specifications.

3. Summary, Implications, and Conclusion

This paper has empirically re-examined the validity of the Gurley-Shaw hypothesis that financial innovations will increase the interest elasticity of money demand. We have employed a hybrid of unit root tests, cointegration tests, and rolling regressions using UK data over the period 1963Q1–2009Q1. Our unit root and cointegration tests have suggested that the variables in the conventional money demand function, such as real money balance, income, and interest rate are I(1) and cointegrated. Under the conditions described in Engle and Granger (1987) and Stock (1987), we have estimated the money demand equation using the log level of variables to obtain direct elasticity estimates in the rolling regression framework. Following the financial market deregulation and innovations that occurred in the late 1970s and throughout the 1980s, the empirical results suggest that the interest elasticity of money demand has exhibited a secular upward trend.

While the results lend support to the Gurley-Shaw hypothesis, they are in sharp contrast with all previous research findings. The results also indicate that the explanatory power of interest rates tend to evaporate in the post-deregulation period when using broad money stock (M4) in the money demand function. These results have important implications in the choice of monetary aggregates in particular and in the conduct of monetary policy in general.

With the adherence to monetarism during the late 1970s and early 1980s, a monetary targeting strategy and the choice of appropriate monetary aggregates became the centerpiece of monetary policy in the UK. Several measures of monetary aggregates (e.g., M0, M1, M3, PSL2, and M4) have been targeted over time. The Bank of England abandoned M1, M3, and M3c in July 1989. The high proportion of non-interest-bearing elements within M1 made its value quite sensitive to interest rate movements. Moreover, it was alleged to provide a distorted picture regarding the immediate purchasing power held by the public due to the exclusion of very liquid bank deposits and building society sight deposits. All these factors tend to lower the significance of M1 as a useful indicator of monetary aggregates (see Goacher, 1993). The M4 aggregate was introduced in 1992 with the purpose of combining all private sector sterling bank deposits and building society deposits and shares within a single measure of money supply to alleviate the problem of distortion caused by switching of funds between the different groups of institutions. Currently, the Bank of England is targeting a narrow monetary aggregate, M0, and a broader aggregate, M4. The official monitoring range for M0 is 0% to 4% growth per annum and for M4 is 3% to 9% per annum.

The usefulness of monetary aggregates as an intermediate target rests on the following attributes: (1) a consistent and predictable relationship between the intermediate target variable and ultimate goal variables such as output, employment, inflation, and exchange rates without any significant feedback from goal variables to the intermediate target variable and (2) the existence of a stable money demand function.

However, as Bernanke and Mishkin (1997) contend, using an intermediate target approach such as money growth is feasible in an optimal framework only if the intermediate target contains all information relevant to forecasting the goal variable. If any variable other than the intermediate target contains marginal information about the future values of the goal variable, then targeting the goal variable, such as inflation or nominal GDP forecasts, should strictly dominate monetary targeting strategy. Furthermore, if a reverse causality flows from a goal variable to an intermediate target variable, no improvement is available by using an intermediate target framework.

In a recent study, Hasan (1998) found that two of the Bank of England’s current monetary aggregates, M0 and M4, are subject to feedback from output and thus may not serve well as good intermediate targets and informational variables in UK monetary policy. Furthermore, in recent years, financial market innovation and deregulation were held to be largely responsible for the breakdown in the statistical relationships between various monetary aggregates on the one hand and nominal income and interest rates on the other (see Goodhart, 1989). These pieces of evidence in conjunction with the findings of this paper therefore suggest a reduced effectiveness of monetary targeting strategy as a stabilization tool. Given the limited information content and the forecasting value of any particular indicators, such as monetary aggregates and interest rates, monetary authorities and policymakers should focus on a plethora of potentially influential real and financial variables which are mutually interactive, e.g., output, employment, exchange rate, real interest rate, the yield curve, and commodity future prices (see Hakkio and Sellon, 1994).

Following the ERM crisis on September 16, 1992, policymakers in the UK have abandoned membership of the ERM and have adopted an explicit inflation target. The official authorities defined the long-run target range for inflation in terms of a retail price index excluding mortgage interest payments (RPIX) as the lower half of the range 1% to 4% until spring 1997 and 2.5% or lower thereafter. Subsequently, after the newly elected Labour Government granted operational independence to the Bank of England, the target range was set at 1.5% to 3.5% with a central target of 2.5%. Currently, the Bank of England has shifted its focus from the monetary aggregates to a much wider array of economic indicators that have shown predictive power for inflation. The bank now monitors monetary aggregates, exchange rates, interest rates, and other variables as indicators of money market conditions. Overall, the results in this paper suggest that the monetary authorities in the UK are moving in the right direction.

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