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Structural Changes and the Role of Monetary Aggregates in the UK

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Highlights

- We investigate the role of Divisia monetary aggregates relative official Simple Sum aggregates in determining output
- Non-parametric tests are conducted to identify breaks in the underlying variables of our model
- The influence of money is found to be time-varying and official Simple Sum aggregates appear to be more affected by nonlinear structures
- Recovery from the financial crisis could potentially have been faster if investors were not hoarding money

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Abstract

We investigate whether or not monetary aggregates are important in determining output. In addition to the official Simple Sum measure of money, we employ the sophisticated weighted Divisia aggregate. We also investigate whether or not the influence of money on output is time varying using data-driven procedures to identify breaks in the data and conduct estimations for the different segments defined by these breaks. We find that structural breaks do exist in some of the variables under investigation and these do influence the relationship between monetary aggregates and output. However, the official Simple Sum aggregate appears to be more affected by the breaks than the theoretically superior Divisia aggregate. In particular, our results show that in some segments of our data, the Simple Sum aggregate does not influence output significantly whereas the Divisia aggregate maintains a significant relationship with output in all segments. We conclude that Divisia money is still influencing output in spite of the diminished role played in monetary policy. Our investigation also suggests that the recovery from the financial crisis using quantitative easing would have been faster if money was not being hoarded.

Keywords: Divisia monetary aggregates, IS curve, Structural breaks, Quantitative easing

JEL: C22, E52

Structural Changes and the Role of Monetary Aggregates

1. Introduction

In the new Keynesian modern macroeconomic school of thought that has evolved from classical Keynesian economics, the monetary policy model contends that monetary aggregates have no influence on the behavioural equations. These consist of:

(i) An IS curve, in which output gap is linked to a real interest rate.

(ii) A Phillips curve, in which inflation is linked to the output gap.

(iii) A policy rule, in which the nominal interest rate is linked to the output gap and inflation.

The vast array of literature provides arguments and empirical evidence for both excluding and also for including monetary aggregates in the behavioural equations. When a central bank fixes the interest rate using a policy rule, monetary aggregates are argued to play a passive role. In such a setting, the central bank allows the money supply to adjust to the level necessary to attain the desired interest rate (Mankiw, 2018, pp. 428). Thus, some argue that changes in the monetary aggregates are already captured by interest rate movements. This belief is reinforced by studies that show monetary aggregates have no or only a minimal role to play in the behavioural equations. Rudebusch and Svensson (2002), for example, using a semi-structural model cl that monetary aggregates do not significantly affect the US output gap. Ireland (2004), using a small structural model for the US, suggests that monetary aggregates fail to enter the IS and Phillips curves that govern the dynamics of output and inflation. On the other hand, Hafer *et al*. (2007), using semi-structural equations, show that monetary aggregates affect the output gap significantly and independently of interest rates. Nelson (2002) provides corroborating evidence for the UK and US using a similar specification. Using a structural model Castelnuovo (2012) shows monetary aggregates have a significant role in shaping US macroeconomic variables such as output. Canova and Menz (2011), using a small scale New Keynesian model, demonstrate that money is statistically significant in explaining output and inflation for the US and UK. These studies therefore appear to contradict the notion that interest rates already encapsulate the information contained in monetary aggregates. This is not surprising as there are claims that although interest rate changes reflect changes in monetary aggregates they do not fully capture all the information in the latter and hence neglect important monetary effects on macroeconomic variables.

The actions of the monetary authorities affect the prices of a number of assets (Meltzer, 1999) and thereby affect their corresponding yields. The short term interest rate, however, is the price of only one of those assets. If the demand for money function is specified as in Friedman (1956), that is, yields such as those obtained from returns on physical assets, for instance property, are included in the specification, then monetary aggregates are able to serve as a proxy for a wide spectrum of yields. Nelson (2003) argues that the advantage monetary aggregates have in such a context is that they are more directly observable than the complete set of yields that matter for aggregate demand[1]. In the light of this argument, the differences between the studies that do not find a role for monetary aggregates in monetary policy models and those that do, can potentially be attributed to factors such as the particular specification of the models and the definition of variables used in addition to the time period employed. Nelson (2002) re-estimates the Rudebusch and Svensson (2002) semi-structural model over a slightly longer time period and using the money base instead of M2 and finds that the monetary aggregate is significant. Castelnuovo (2012) and Hafer *et al*., (2007) find that the significance of monetary aggregates improves when M2 is used in contrast to narrower measures. Canova and Ferroni (2011, pp. 74) state that the majority of structural models in the literature are time invariant, but Canova and Menz (2011) and Castelnuovo (2012) show that the impact of monetary aggregates on macroeconomic variables such

[1] Monetary aggregates can also influence output through the bank lending channel and the real balance effects. However there are claims that they are not as important as the one described here. See for example (Oliner and Rudebusch (1995) and Nelson (2003)).

as output and inflation is time-varying. Canova and Ferroni (2011) illustrate that statistical filtering devices induce important measurement errors in the estimation of cyclical components of variables, subsequently affecting the parameters of structural models. They exemplify the distortionary effects caused to structural models by replicating Ireland's (2004) model specifications and testify that monetary aggregates would play a significant role in the determination of output and inflation, if Ireland's (2004) model relied on an approach that used multiple filtering devices, rather than just a single filtering device.

The literature which investigates whether or not monetary aggregates are important for the determination of output as described above declined following the abandonment of monetary targeting as the mainstay of monetary policy in the late 1980s. This paper will therefore put this critical debate firmly back on the agenda. Furthermore, we shed new light on whether or not the quantitative easing measures, aimed at increasing spending and therefore output, recently undertaken by the Bank of England, are serving their purpose. In particular, we examine the importance of monetary aggregates using a semi-structural model similar to the one's used in Rudebusch and Svensson (2002) and Nelson (2002), whilst also taking into account i) the time variation properties of the model, ii) the issues surrounding the alternative methods of constructing the aggregates, that is the superiority of the Divisa index vis a vis the Simple Sum index as detailed respectively below and iii) the use of three differing statistical filters.

(i) Time variation properties of the model. The small number of studies that investigate the nonlinear properties of the model tend to hypothesise about potential break points, based on prior knowledge of certain specific events that could have affected the underlying variables. The next step then is to perform a test, such as the Chow (1960) test, to ascertain whether or not there is indeed a structural break. If there is evidence to that effect, the models in these studies are re-estimated for the post-break period. For example, Hafer *et al*., (2007) hypothesise that there is a break in 1982Q4 while estimating the IS curve for the US. They note that this date coincides with dramatic shifts in the velocities of some monetary aggregates for the US. Hafer and Jones (2008) hypothesise that there is a break in 1973Q3 for their sample of countries that include the UK and US, mentioning the end of the Bretton Woods as a reason. The novelty that we are bringing to this debate is that we will rely on a set of statistical procedures to non-parametrically identify breaks in the mean and/or volatility dynamics of each of the underlying variables of the model. Thus, our approach is data-driven, less subjective and less likely to ignore certain events that might be considered small but that could potentially lead to breaks in macroeconomic variables. In particular, we use the 'Nominating-Awarding' procedure in objectively identifying the breaks in the mean and/or volatility dynamics of the underlying variables of our models (see for example Karoglou, 2010; Bissoondeeal *et al*., 2014). Thus, by identifying and taking into account the breaks in the mean and/or volatility dynamics of the variables, we attempt to ensure that the parameters of our models are stable over the estimation horizon. Section 3 outlines the sets of tests involved in this procedure.

(ii) Two alternative methods for aggregating the constituent component assets of money. Whilst, there is a consensus among some studies that the type of monetary aggregates used in models can influence their relevance to the determination of inflation and output, their experimentations have been confined to different levels of aggregation of official measures of money such as M0, M1 and M2; see, for example, Castelnuovo (2012) and Hafer *et al*., (2007). Official measures of money are traditionally constructed by simply adding up the constituent component assets and hence are usually also referred to as Simple Sum aggregates. There is a strand of literature which investigates the stability of money demand functions that also looks into the properties of the theoretically superior Divisia monetary aggregates (Barnett, 1978, 1980, Vlassopolous, 2010, and Anderson and Jones, 2011) in addition to the official Simple Sum measures. The Divisia aggregate weights the asset components according to the liquidity services they provide and thus is a more complex weighted aggregate when compared to the Simple Sum aggregate which gives equal weighting to its constituents of either zero or 1, depending upon whether or not the assets appears in the chosen aggregate or not. The rationale for giving different weights is linked to the level of liquidity services each component asset provides. Thus notes and coins are held primarily for transaction services and hence more closely linked to economic activity, therefore receiving the highest weight in the construction of the aggregate. Other components ranging from short term deposits to long term deposits, are primarily held for savings purposes and therefore are less useful in providing transactions services, therefore receiving smaller weights. The support in favour of using a Divisia aggregate is gaining in momentum, see for example studies by Reimers (2002) and Binner *et al*., (2009). Both find that the Divisia aggregate enters significantly a semi-structural equation for the Euro area. This paper will contribute to the literature on the Divisia Index debate by investigating the relative performance of Divisia vis a vis Simple Sum aggregates for the UK, and, for the first time our work will be within the context of structural breaks identification.

(iii) Three different statistical filters. In addition to using the conventional HP filter, we will also employ a second order polynomial, following Binner *et al*., (2009), and the Hamilton filter (2017) in order to extract the cyclical component of output.

The remainder of the paper is organised as follows. Section 2 outlines the structural breaks tests. The model and the data are discussed in Section 3, and estimations are presented in Section 4. Section 5 provides our concluding remarks and offers suggestions for future research.

2. Structural breaks tests

In this section, we describe the 'Nominating-Awarding' procedure of Karoglou (2009, 2010). As mentioned earlier, this procedure is data-driven and therefore does not require any guesses about potential breaks. Other data driven procedures exist but they essentially rely on a single test. In contrast the ‘Nominating-Awarding’ procedure relies on a battery of tests. The idea behind this procedure is to circumvent the low power of individual tests which may be brought about by the underlying dynamics of the series being tested. Additionally, in the spirit of robustness, the procedure consists of two stages, each comprised of its own battery of statistical tests. The first stage, the ‘Nominating break dates’ stage, is essentially about identifying possible break dates. The second stage, the ‘Awarding break dates’ stage, is essentially about ascertaining that the segments on either side of a possible ‘break date’ cannot be united, in other words, it aims to discard breaks that may have been falsely identified. In what follows we briefly outline the details of each stage.

2.1 The ‘Nominating break dates’ stage

In the ‘Nominating break dates’ stage we use the following CUSUM-type tests:

(a) IT - Inclan and Tiao, (1994)

(b) ASC_1 - The first test of Sansó, Aragó, and Carrion (2003)

(c) ASC_2^{BT}, ASC_2^{QS}, ASC_2^{VH} - The second test of Sansó, Aragó, and Carrion (2003), with the Bartlett kernel, the Quadratic Spectral kernel, both used with the automatic procedure of Newey and West (1987) for bandwidth selection and the Vector Autoregressive HAC or VARHAC kernel of den Haan and Levin, 1998 which bypasses the bandwidth selection issue correspondingly

(d) KL_{BT}, KL_{QS}, KL_{VH} - the refined by Andreou and Ghysels, (2002) version of the Kokoszka and Leipus, (1999, 2000) test with the Bartlett kernel, the Quadratic Spectral kernel, and the VARHAC kernel correspondingly.

(e) LMT - Lee, Maekawa and Tokutsu (2003)

One of the key reasons for selecting these tests is that in addition to being able to detect changes in the volatility dynamics, they can also identify shifts in the mean. Moreover, their properties have been extensively investigated; see for example, Andreou and Ghysels (2002), Sansó, Aragó, and Carrion (2003). Karoglou (2006a,b) shows that, the performance of these tests depends on the underlying data generating process of the variable under investigation. Given that the true data generating process is not known, in order to increase our confidence in these tests, we only select a break date if at least two of tests suggest a break at the 5% level.

Given that a stochastic process may exhibit more than one break, we apply each of the aforementioned tests using the following iterative algorithm:

1. Calculate the test statistic of (a), (b), (c), (d) and (e) using the available data.
2. If the statistic is above the critical value, (i.e., rejection of the null of no breaks), split the particular sample into two parts at the date at which the value of a test statistic is maximized.
3. Repeat steps 1 and 2 for the first segment until no more (earlier) change-points are found.
4. Mark this point as an estimated change-point of the whole series.
5. Remove the observations that precede this point, i.e. those that constitute the first segment.
6. Consider the remaining observations as the new sample and repeat steps 1 to 5 until no more change-points are found.

2.2 The 'Awarding break dates' stage

In the 'Awarding break dates' stage further statistical tests that do not take into account the time series dimension of the data are conducted to ensure that the contiguous segments identified in the 'Nominating break dates stage' have sufficiently different statistical properties and specifically:

(i) the means of the contiguous segments are statistically different, as suggested by the t-test and the Satterthwaite-Welch t-test which is more robust when the contiguous segments do not have the same variance

(ii) the variances of the contiguous segments are statistically different (as suggested by the battery of tests which is described below)

This procedure is repeated until no more segments can be united.

With regards to ii, the battery of tests involved in testing for the homogeneity of variances of distinct samples are:

(a) the standard F-test; this requires equal sample sizes and is sensitive to departures from normality;

(b) the Siegel-Tukey test with continuity correction, Siegel and Tukey (1960) and Sheskin (1997); this is based on the assumption that the samples are independent and have the same median;

(c) the adjusted Bartlett test, see Sokal and Rohlf (1995) and Judge, et al. (1985). This is also robust when the sample sizes are not equal, despite still being sensitive to departures from normality. Its adjusted version makes use of a correction factor for the critical values and the arcsine-square root transformation of the data to conform to the normality assumption;

(d) the Levene test (1960); this is an alternative to the Bartlett test which is less sensitive to departures from normality;

(e) and the Brown-Forsythe (1974) test; this is a modified Levene test, substituting the group mean by the group median, and appears to be superior in terms of robustness and power when scores are highly skewed or samples are relatively small.

Similar to the tests in 'Nominating break dates' stage, the ones above may suffer from low power due to the underlying dynamics of the series being tested. Thus, we award the 'break date' property on a nominated 'break date' only if at least two of the tests are statistically significant at the 5% level.

3. Model and Data

3.1 IS curve specification

In order to be consistent with the relevant literature, e.g., Rudebusch and Svensson (2002) and Hafer *et al*., (2007), we estimate the following IS curve equation:

$$y_{gt} = \beta_0 + \beta_1 y_{gt-1} + \beta_2 y_{gt-2} + \beta_3 r_{t-1} + \beta_4 m_{t-1} + \varepsilon_{2t} \qquad (1)$$

In these equations the variable y_{gt} denotes the output gap, r_t denotes the short term real interest rate and m_t denotes the four quarter change in the log of real money supply. The output gap is a measure of the difference between the actual output and its potential output. A positive value of the output gap implies output is above potential output whereas a negative value implies output is below its potential output. The output gap is computed using three different statistical filters: by detrending the logarithm of real gross domestic product (GDP) with (i) the conventional Hodrick and Prescott (1997) filter and (ii) the Hamilton (2017) filter; and (iii) by regressing GDP against a constant, t and t^2 and treat the residuals from the regression as a measure of output gap following Binner *et al*., 2009. These filters will be referred to as the HP, Hamilton and QD filters respectively. The short term real interest rate is measured as the difference between the four-quarter average of the nominal rate and four quarter growth rate of the consumer price index (CPI). Nominal output and nominal money supply are converted to their corresponding real values using CPI.

3.2 Data

UK quarterly data for the period 1977Q1 to 2013Q4 are used. The starting period is constrained by the availability of Divisia data from the Bank of England's statistical interactive database on their website. Simple Sum and Divisia M4 aggregates were obtained from the Bank of England's website[2]; these are essentially the broadest level of aggregation for the UK. Data on CPI, GDP and Treasury bill rate (TBR) are obtained from DataStream. Apart from the Treasury bill rate, all the variables are in seasonally adjusted form. Graphical representations of the series are given in Figure 1.

4. Results

4.1 Break test results

All the variables referred to in the earlier section were subjected to the structural break tests. The results are reported in Table 1. In particular, Panel A reports the results from the 'Nominating break dates' stage, where, as discussed in Section 2.1, we adopt a 'break date' if at least two of the tests suggest a break at the 5% level. Panel B reports the results from the 'Awarding break dates' stage, where, as discussed in Section 2.2, the status of a break is awarded if at least two of the tests suggest that the segments on either side of the 'break date' cannot be united as the mean and/or the variance of the segments are different. The tests in the 'Awarding break dates' stage confirms all the 'break dates' identified in the first stage of the test as breaks and details of these are as follows:

(i) A break in 2008Q3 in the Simple Sum monetary aggregate, which seems to correspond to the recent financial crisis which affected the UK and many other countries.

(ii) Two breaks in GDP; the one in 1980Q3 corresponds to the recession occurring around that time in the UK; the other in 2008Q3 corresponds to the recent financial crisis.

[2] http://www.bankofengland.co.uk/boeapps/iadb/

(iii) Two breaks in CPI; the one in 1981Q4 corresponds to the recession at the time; the break in 1991Q3 appears to correspond to the UK exiting the exchange rate mechanism (ERM).

(iv) A break in 1993Q1 in TBR which also seems to correspond to the exit of the UK from ERM.

[Please insert Table 1 here]

Thus based on our breaks tests it appears our data sample has been affected by three main events: a recession in early 1980s, the UK exiting the ERM in 1992 and the recent financial crisis. The resulting breaks from these events create four segments in the data which we proceed to analyse separately. The segment before the first break is very small and therefore will not be considered for further analysis. Thus, the three segments that will be considered are defined as Segment 1: 1982Q1 to 1991Q3; Segment 2: 1993Q2 to 2008Q2; Segment 3: 2008Q4 to 2013Q4. For comparative purposes, we will also estimate our model for the entire sample.

4.2 IS curve estimation results

IS curve estimation results are reported in Table 2; Panels A, B, C and D provide estimates for the whole sample, 1982Q1 to 1991Q3, 1993Q2 to 2008Q2 and 2008Q4 to 2013Q4 respectively. The subcategories of the panels distinguish between estimates obtained using the HP, QD and Hamilton filters. The numbers in the parentheses are *t*-statistics[3]. Given that purpose of the paper is to contribute to the debate on whether or not monetary aggregates play a role in the determination of macroeconomic variables such as output, we will focus the discussion on their statistical significance at the 5% level in the IS curve. Looking at the result for the whole sample, it appears the Divisia monetary aggregate is

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[3] Given that recent some studies discuss the important role of the real interest rate relative to its natural rate in determining output, see, for example, Canzoneri et al., (2015), we re-estimate all the models employed in producing the results in Table 2, using $r_t - r_t^*$, where r_t^* represents the natural rate of interest, instead of r_t in Equation 1. The results are not shown here for reasons of brevity, but they show no difference in the statistical significance of money when compared to results in Table 2.

important in determining output across all statistical filters. The results are somewhat mixed for the Simple Sum aggregate – it achieves statistical significance with the HP filter, marginally misses the 5% significance level with the QD filter, and is not significant with the Hamilton filter .

[Please insert Table 2 here]

Looking at results from different segments, it appears that the impact of monetary aggregates on output is time-varying. More specifically, the magnitude, and in some cases the significance, of the coefficients of monetary aggregates change across different segments. In the first segment, 1982Q1 to 1991Q3, both measures of money are significant at the 5% level for all statistical filters. It is worth noting that there is a substantial overlap between this segment and the monetary targeting regime in the UK. For the second segment, 1993Q2 to 2008Q2, the Simple Sum aggregate does not achieve statistical significance with any of the filters. In contrast, the Divisia aggregate is able to explain output at the 5% level when the QD and Hamilton filters are employed. For the third segment, 2008Q4 to 2013Q4, the Simple Sum aggregate does not contribute to the determination of output with any of the filters; the Divisia aggregate on the other hand is highly significant with the HP and QD filers filters. It is interesting to note that the Simple Sum aggregate is not significant in the last two segments which operate under an inflation targeting regime when compared to the monetary targeting regime of the first segment. The Divisia aggregate, in contrast, displays significance, with at least some of the statistical filters, in all segments irrespective of a monetary or inflation targeting regime. It is also interesting to note that the Divisia aggregate is significant in the post financial crisis segment during which the Bank of England embarked on the quantitative easing program. The significance of the Divisia aggregate, to some extent, suggests that quantitative easing has helped boost the UK economy. The question then is why the Divisia aggregates affect output significantly in that segment when the Simple Sum aggregate does not? The answer may lie in the difference in the way the two aggregates are constructed. As discussed earlier, the Simple Sum aggregate gives an equal weight of one to each asset component whereas the Divisia aggregate gives weight proportional to their degree of liquidity. One may argue that the Divisia aggregate is more representative of highly liquid assets whereas the Simple Sum aggregate is more representative of less liquid assets, given their presence in a higher ratio. Thus, the fact that the Divisia aggregate is significant but the Simple Sum aggregate is not, may signify that assets with higher level of liquidity services are having a more significant impact on output. Thus these results appear to lend support to the argument that the recovery from the financial crisis could have been faster if firms, and consumers, were not hoarding money, as has been reported by many commentators, instead of investing or spending it. This argument is based on the assumption that the hoarded money would be kept in the form of relatively high interest yielding monetary assets and hence the Simple Sum aggregate would be more representative of them.

5. Summary and Conclusion

We set out to investigate whether or not monetary aggregates, which are largely ignored in monetary policymaking, have a role to play in determining output using a semi-structural model. This exercise can also provide an indication as to whether or not quantitative easing has been successful in boosting output in the UK. In particular, we wish to establish whether the role of monetary aggregates are sensitive to (i) the time period employed, (ii) the types of monetary aggregates employed, and (iii) the types of filters used in detrending output. In terms of investigating the time variation properties, we use data driven structural break tests to identify breaks in our data sample. In addition to employing the commonly used official Simple Sum measure of money, we also employ the Divisia aggregate which gives different weights to constituent component assets based upon the degree of monetary services provided. A second order polynomial and the Hamilton filter are also employed in addition to the frequently used HP filter in extracting the cyclical component of output.

The statistical filters appear to have some impact on the statistical significance of money but these appear quite minimal. Using the HP filter as the benchmark, the results differ twice in eight comparisons for the Simple Sum aggregate. For the Divisia aggregate the results differ three times in eight comparisons – however, using the other filters appears to increase its chances of being significant. Time period and the way money is defined and constructed appears to influence the role played by monetary aggregates strongly. The structural breaks tests identify a number of breaks in the mean and/or volatility dynamics of the underlying variables of our semi-structural model, which partition our data sample into segments. The results for the different segments suggest that the relationship of the monetary aggregates with output is time-varying. The time variation feature is more striking with the Simple Sum aggregate. Although the magnitude of the Divisia aggregate changes somewhat in different segments, its statistical significance remains fairly stable. In contrast, for the Simple Sum aggregate both the magnitude and statistical significance changes in different segments. Thus the results, in particular, the Divisia results suggest that money is still playing an important role in influencing the economy in spite of its somewhat diminished role in monetary policymaking. The stronger link between the Divisia aggregate and output is not surprising, given that, as mentioned earlier, it gives higher weights to assets that are more relevant for transactions when compared to the Simple Sum aggregate. The differing weighting mechanisms also potentially explain why the Divisia aggregate is significant in the final segment which encompasses the quantitative easing episode, and the Simple Sum aggregate is not. As discussed earlier, the Divisia aggregate is more representative of assets which are at the higher end of liquidity spectrum and the Simple Sum aggregate can be considered more representative of less liquid assets and thus when the results from the two aggregates are looked at in conjunction for the final segment, they suggest that the recovery from the financial crisis could have been faster if firms, and consumers, were not hoarding money, in relatively higher yielding monetary assets, instead of investing or spending it. Future work is recommended to delve deeper into this issue to provide a more definitive answer with respect to whether or money hoarding has slowed down the recovery from the financial crisis and, more specifically, whether the UK is in a liquidity trap.

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Table 1: Structural breaks tests

Panel A: The results of the 'Nominating breakdates' stage

	IT	ASC$_1$	ASC$_2^{BT}$	ASC$_2^{QS}$	ASC$_2^{VH}$	KL$_{BT}$	KL$_{QS}$	KL$_{VH}$	LMT	Adopted
Simple Sum	2008Q3**	2008Q3**	2008Q3*	2008Q3**	-	-	2008Q3**	-	2008Q3**	2008Q3**
	2010Q2*	0	-	-	-	-	-	-	-	-
DIVISIA	1986Q2*	-	-	-	-	-	-	-	-	-
	1989Q4*	-	-	-	-	-	-	-	-	-
GDP	1980Q3**	1980Q3*	-	1980Q3*	-	-	1980Q3*	-	1980Q3*	1980Q3**
	2008Q2**	2008Q2*	-	2008Q2*	-	-	2008Q2*	-	2008Q2*	2008Q2**
CPI	1981Q4**	1981Q4**	-	1981Q4**	-	-	1981Q4**	-	1981Q4**	1981Q4**
	1991Q3**	1991Q3**	-	1991Q3**	-	-	1991Q3**	-	1991Q3**	1991Q3**
	2007Q3*	-	-	-	-	-	-	-	-	-
TBR	1993Q1**	1993Q1**	1993Q1**	1993Q1**	1993Q1**	1993Q1**	1993Q1**	1993Q1**	1993Q1**	1993Q1**
	2008Q4**	-	-	-	-	-	-	-	-	-
	2009Q2**	-	-	-	-	-	-	-	-	-
	2010Q2*	-	-	-	-	-	-	-	-	-

Panel B: The results of the 'Awarding breakdates' stage

Segments	**t-test**	**Satterthwaite-Welch t-test**	**F-test**	**Siegel-Tukey**	**Bartlett**	**Levene**	**Brown-Forsythe**
CPI 1 & 2	6.76**	5.27**	5.50**	2.24*	19.00**	7.15**	4.84*
CPI 2 & 3	9.49**	7.84**	2.82**	2.35*	15.59**	9.92**	9.53**
Output 1 & 2	8.98**	6.81**	2.05	4.49**	3.53	1.99	1.3
Output 2 & 3	5.62**	4.38**	2.13*	1.68	5.85*	5.35*	4.82*
Simple Sum 1 & 2	5.32**	3.48**	3.49**	4.70**	17.54**	12.24**	7.09**
TBR 1 & 2	-0.17	-0.15	8.32**	6.21**	73.39**	53.69**	52.77**

Notes:

(i) The variables were transformed to first differences before the tests as they are required to be stattionary.

(ii) * and ** indicate significance at the 5 and 1 percent levels respectively,

Table 2: IS curve estimations (Numbers in the parentheses are *t*-statistics)

Panel A1: Whole sample, HP filter

	Standard IS Curve	IS curve with monetary aggregates	
		Simple Sum	Divisia
β_0	0.001 (0.57)	-0.001 (-0.52)	-0.001 (-1.38)
y_{gt-1}	0.859 (10.13)	0.819 (9.58)	0.707 (8.37)
y_{gt-2}	0.001 (0.017)	0.020 (0.24)	0.129 (1.56)
r_{t-1}	-0.014 (-0.54)	-0.053 (-1.74)	-0.072 (-2.74)
m_{t-1}	-	0.045 (2.24)	0.103 (4.89)
R^2	0.73	0.74	0.77
DW	1.99	2.00	1.93

Panel A2: Whole sample, QD filter

	Standard IS Curve	IS curve with monetary aggregates	
		Simple Sum	Divisia
β_0	-0.004 (-2.80)	-0.006 (-3.43)	-0.008 (-5.71)
y_{gt-1}	1.096 (12.9)	1.060 (12.30)	0.847 (9.65)
y_{gt-2}	-0.114 (-1.33)	-0.093 (-1.09)	0.121 (1.39)
r_{t-1}	0.069 (2.32)	0.034 (0.98)	0.014 (0.49)
m_{t-1}	-	0.048 (1.94)	0.143 (5.78)
R^2	0.97	0.97	0.97
DW	2.11	2.10	1.96

Panel A3: Whole sample, Hamilton filter

	Standard IS Curve	IS curve with monetary aggregates	
		Simple Sum	Divisia
β_0	-0.002 (-0.63)	-0.003 (-0.96)	-0.008 (-2.60)
y_{gt-1}	0.968 (11.18)	0.961 (11.04)	0.084 (9.55)
y_{gt-2}	-0.113 (-1.33)	-0.115 (-1.34)	-0.097 (-1.19)
r_{t-1}	0.062 (0.96)	0.027 (0.35)	-0.017 (-0.26)
m_{t-1}	-	0.042 (0.90)	0.224 (4.02)
R^2	0.79	0.79	0.81
DW	2.03	2.03	2.04

Panel B1: 1982Q1 to 1991Q3, HP filter

	Standard IS Curve	IS curve with monetary aggregates	
		Simple Sum	Divisia
β_0	0.002 (0.29)	-0.009 (-1.48)	0.002 (0.39)
y_{gt-1}	0.943 (5.51)	0.634 (3.74)	0.681 (3.99)
y_{gt-2}	-0.033 (-0.20)	0.219 (1.36)	0.237 (1.39)
r_{t-1}	-0.028(-0.25)	-0.114 (-1.15)	-0.139 (-1.33)
m_{t-1}	-	0.185 (3.67)	0.114 (3.29)
R^2	0.83	0.88	0.87
DW	2.01	2.14	1.90

Panel B2: 1982Q1 to 1991Q3, QD filter

	Standard IS Curve	IS curve with monetary aggregates	
		Simple Sum	Divisia
β_0	-0.000 (-0.01)	-0.019(-2.34)	-0.001 (-0.20)
y_{gt-1}	1.189 (7.12)	0.755 (4.24)	0.727 (4.11)
y_{gt-2}	-0.237 (-1.44)	0.125 (0.75)	0.224 (1.28)
r_{t-1}	-0.020 (-0.17)	-0.094 (-0.89)	-0.157 (-1.47)
m_{t-1}	-	0.245 (3.96)	0.170 (4.18)
R^2	0.92	0.94	0.95
DW	2.21	2.18	1.92

Panel B3: 1982Q1 to 1991Q3, Hamilton filter

	Standard IS Curve	IS curve with monetary aggregates	
		Simple Sum	Divisia
β_0	0.012 (0.96)	-0.009 (-0.58)	0.001 (0.10)
y_{gt-1}	0.987 (5.85)	0.810 (4.57)	0.557 (3.34)
y_{gt-2}	-0.117 (-0.70)	-0.092 (-0.59)	-0.010 (-0.08)
r_{t-1}	-0.199 (-0.89)	-0.290 (-1.34)	-0.338 (-1.84)
m_{t-1}	-	0.314 (2.28)	0.404 (4.46)
R^2	0.79	0.82	0.87
DW	1.96	2.06	2.08

Panel C1: 1993Q2 to 2008Q2, HP filter

	Standard IS Curve	IS curve with monetary aggregates	
		Simple Sum	Divisia
β_0	0.008 (2.58)	0.005 (1.16)	0.008 (2.25)
y_{gt-1}	0.690 (5.24)	0.680 (5.12)	0.689 (5.18)
y_{gt-2}	0.215 (1.52)	0.185 (1.25)	0.220 (1.53)
r_{t-1}	-0.191 (-2.31)	-0.167 (-1.88)	-0.192 (-2.31)
m_{t-1}	-	0.029 (0.75)	-0.009 (-0.23)
R^2	0.77	0.77	0.77
DW	1.88	1.87	1.89

Panel C2: 1993Q2 to 2008Q2, QD filter

	Standard IS Curve	IS curve with monetary aggregates	
		Simple Sum	Divisia
β_0	0.007 (2.07)	0.007 (1.53)	0.003 (0.85)
y_{gt-1}	0.693 (4.72)	0.692 (4.67)	0.584 (4.16)
y_{gt-2}	0.268 (1.83)	0.264 (1.77)	0.313 (2.28)
r_{t-1}	-0.155 (-1.55)	-0.156 (-1.55)	-0.263 (-2.66)
m_{t-1}	-	0.009 (0.20)	0.152 (3.18)
R^2	0.98	0.98	0.98
DW	1.68	1.67	1.74

Panel C3: 1993Q2 to 2008Q2, Hamilton filter

	Standard IS Curve	IS curve with monetary aggregates	
		Simple Sum	Divisia
β_0	0.021 (3.04)	0.022 (2.58)	0.016 (2.29)
y_{gt-1}	0.561 (4.46)	0.563 (4.42)	0.504 (3.99)
y_{gt-2}	-0.219 (-1.85)	-0.217 (-1.78)	-0.282 (-2.35)
r_{t-1}	-0.129 (-0.78)	-0.135 (-0.78)	-0.132 (-0.82)
m_{t-1}	-	-0.008 (-0.12)	0.153 (1.97)
R^2	0.27	0.27	0.32
DW	1.90	1.91	1.85

Panel D1: 2008Q4 to 2013Q4, HP filter

	Standard IS Curve	IS curve with monetary aggregates	
		Simple Sum	Divisia
β_0	-0.007 (-1.33)	-0.007 (-1.01)	-0.015 (-4.03)
y_{gt-1}	0.830 (2.89)	0.828 (2.75)	0.351 (1.66)
y_{gt-2}	-0.209 (-0.98)	-0.206 (-0.89)	0.208 (1.27)
r_{t-1}	-0.222 (-1.27)	-0.231 (-0.86)	-0.473 (-3.80)
m_{t-1}	-	0.002 (0.05)	0.244 (4.92)
R^2	0.60	0.60	0.84
DW	1.84	1.84	2.15

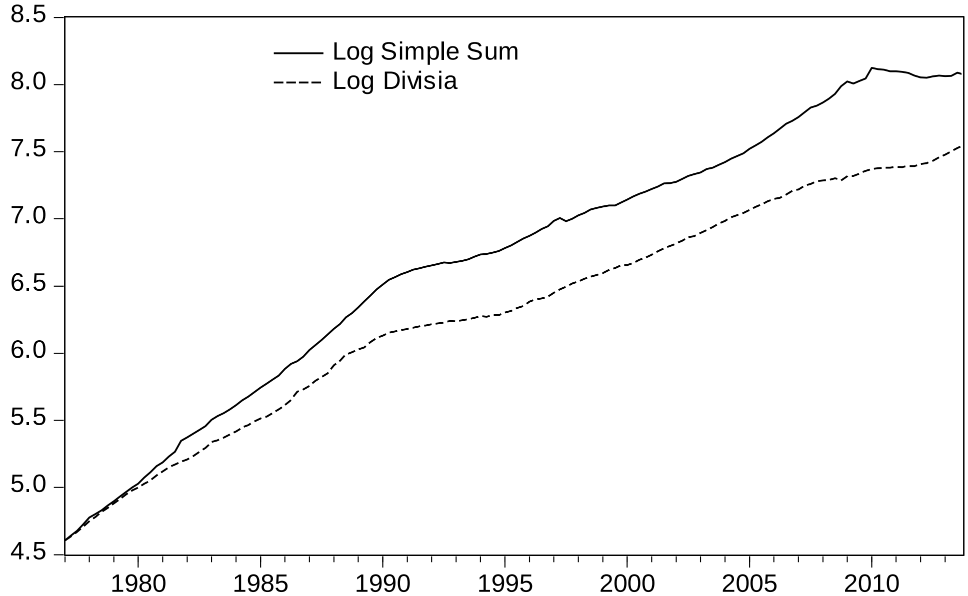
Panel D2: 2008Q4 to 2013Q4, QD filter

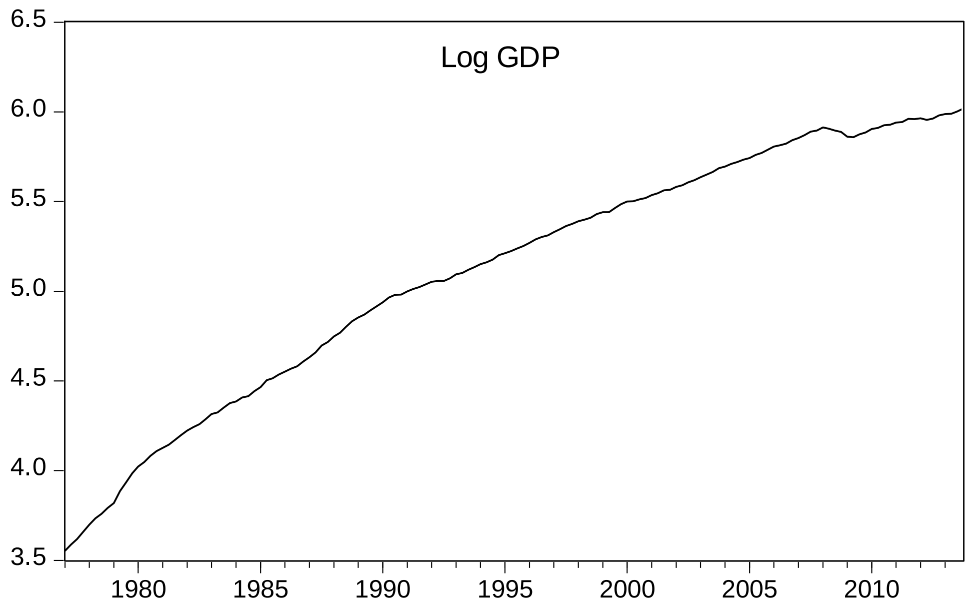
	Standard IS Curve	IS curve with monetary aggregates	
		Simple Sum	Divisia
β_0	-0.014 (-2.25)	-0.028 (-2.60)	-0.018(-3.43)
y_{gt-1}	1.019 (4.31)	0.795 (2.96)	0.764 (3.61)
y_{gt-2}	-0.113 (-0.51)	0.050 (0.21)	0.233 (1.09)
r_{t-1}	0.080 (0.44)	-0.189 (-0.77)	-0.293 (-1.52)
m_{t-1}	-	0.092 (1.56)	0.234 (3.03)
R^2	0.96	0.97	0.98
DW	2.05	2.01	1.89

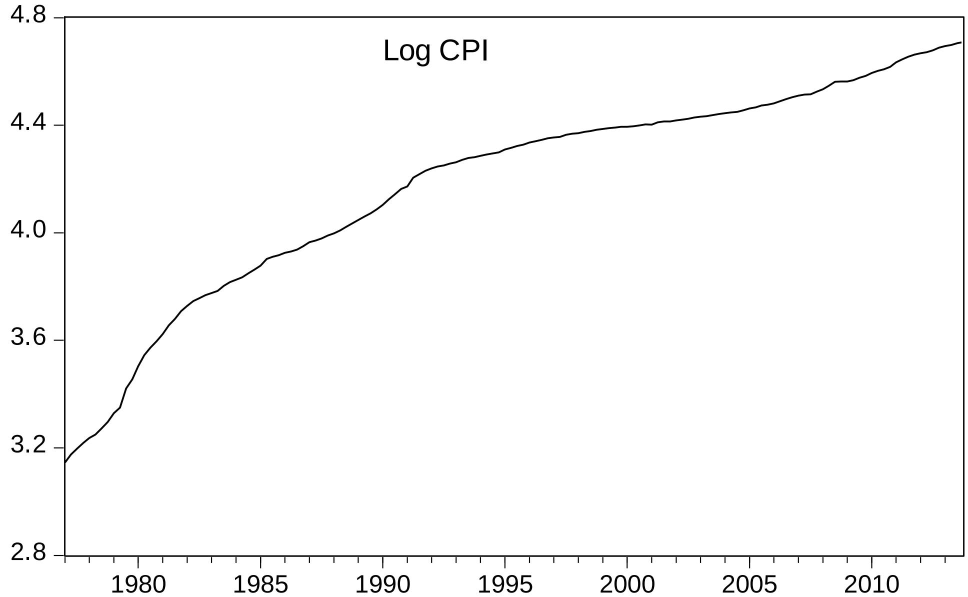
Panel D3: 2008Q4 to 2013Q4, Hamilton filter

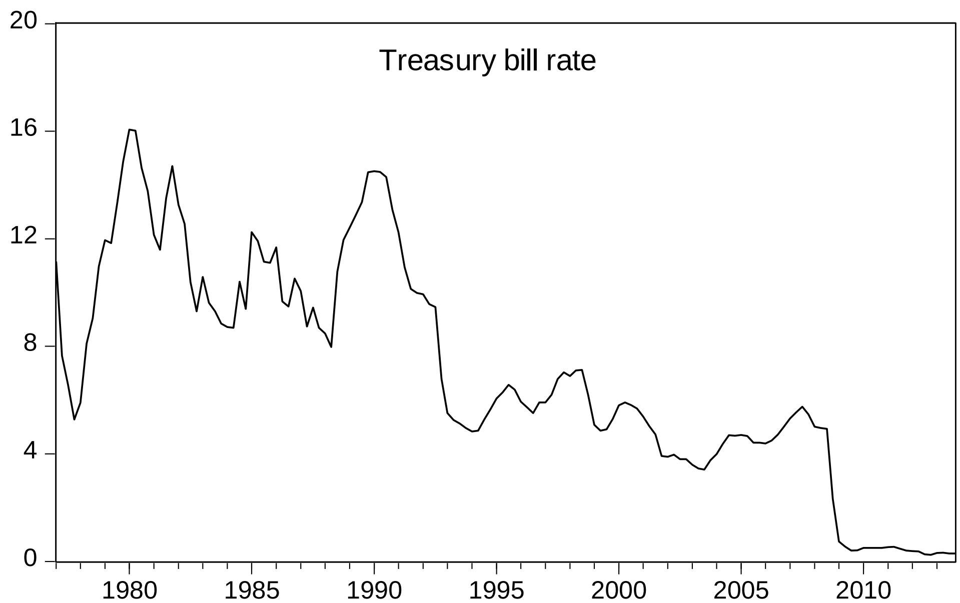
	Standard IS Curve	IS curve with monetary aggregates	
		Simple Sum	Divisia
β_0	-0.030 (-2.57)	-0.041 (-2.85)	-0.031 (-2.68)
y_{gt-1}	1.114 (5.30)	1.049 (4.92)	1.030 (4.85)
y_{gt-2}	-0.500 (-2.72)	-0.396 (-1.98)	-0.341 (-1.61)
r_{t-1}	-0.74 (-2.02)	-1.239 (-2.30)	-0.802 (-2.24)
m_{t-1}	-	0.137 (1.24)	0.241 (1.42)
R^2	0.82	0.83	0.84
DW	2.37	2.17	2.50

Figure 1: Graphical representation of series






Log CPI
4.8
4.4
4.0
3.6
3.2
2.8
1980
1985
1990
1995
2000
2005
2010


Treasury bill rate
20
16
12
8
4
0
1980
1985
1990
1995
2000
2005
2010